**University of Alberta**

# Adolescent Facial Morphology and TMJ Internal Derangement

by

Brian Nebbe

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in

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The undersigned certify that they have read, and recommend to the Faculty of graduate Studies and Research for acceptance, a thesis entitled Adolescent Facial Morphology and TMJ Internal Derangement submitted by Brian Nebbe in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Medical Sciences (Medicine).

PW Major

Dr PW Major (Supervisor)

P.S. Allen

Dr PS Allen (Supervisor)

Susan W. Herring

Dr SW Herring (Committee member)

J Bamforth

Dr S Bamforth (Committee member)

Gary Faulkner

Dr GM Faulkner (Committee member)

DW Morrish

Dr DW Morrish (Committee member)

A Russell

Dr AS Russell (Committee member)

## DEDICATION

To Canada and Canadians, for providing a home away from home.

## ABSTRACT

The purpose of this study was to investigate whether craniofacial morphology in an adolescent sample was associated with temporomandibular joint (TMJ) disc position. Furthermore, associations between disc position and clinical signs and symptoms were investigated. A pilot study was conducted on 32 adolescent individuals to test the association between disc displacement and craniofacial morphology. The results of the pilot study were encouraging but deficiencies in classification of disc position using subjective interpretation of magnetic resonance images (MRI) were encountered.

A definitive study sample of 110 adolescent females and 70 males between 10 and 17 years of age were studied regardless of TMJ signs or symptoms. In place of subjective interpretation of MRIs, quantification of TMJ disc length and disc displacement was carried out on MRIs of the TMJs using standardized reference planes transferred from lateral cephalometric radiographs. Interobserver reliability studies showed that the quantification technique had moderate to substantial interobserver agreement when applied by four examiners with varied backgrounds and training in MRI interpretation. Furthermore, the quantification technique showed that as the magnitude of disc displacement increased the sagittal dimensions of the disc reduced.

The quantification technique was applied to MR images obtained from the adolescent sample to determine disc status. This information was used in separate multivariate analyses for males and females to test the association between disc displacement and

facial morphology. In these analyses the effect of age on facial dimensions was controlled by using polynomial regression techniques. Regardless of gender, internal derangement of the TMJ was shown to be associated with a reduction in posterior facial height, a reduction in sagittal mandibular dimensions, an increased mandibular plane angle relative to mid-sagittal cranial base reference planes, and a moderate increase in anterior facial height. Alterations in vertical and sagittal maxillary position and dimensions were not consistently noted.

Clinical signs and symptoms were entered into regression equations to establish whether these variables could be used to predict disc position. Only reproducible opening joint sounds were consistently entered in both male and female models. Clinical signs and symptoms did not appear to be adequate in predicting disc displacement.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| $\kappa$ | Kappa statistic |
| % | Percentage |
| $\omega$ | Larmor frequency |
| $\gamma$ | Gyromagnetic ratio |
| $\tau$ | Time constant |
| $\Sigma$ | Sum of |
| $\beta_o$ | Strength of applied magnetic field |
| $^{o}$ | Degrees |
| 6/ANS-PNS | Maxillary mesiobuccal cusp tip perpendicular to palatal plane |
| ANOVA | Analysis of Variance |
| ANS | Anterior nasal spine |
| ANS’ | A point on upper contour of ANS where vertical thickness is 3 mm |
| ANS” | A point on lower contour of ANS spine where vertical thickness is 3 mm |
| ANS - PNS | Palatal plane |
| ANS-Me | Anterior nasal spine - Menton |
| ANS-PNS/Go-Me | Anterior nasal spine - Posterior nasal spine/ Gonion - Menton |
| Ar | Articulare |
| Ar-Go | Articulare - Gonion |
| Ar-Go-Me | Articulare - Gonion - Menton |
| Ar-Me | Articulare - Menton |
| Ba | Basion |

| | |
|---|---|
| Ba-N | Basion - Nasion |
| BaN/Ptm-Gn | Basion - Nasion/ Pterygomaxillary point - Gnathion |
| bFGF | Basic Fibroblast Growth Factor |
| BMS | Source of variations between slices |
| BN | Brian Nebbe |
| C.I. | Confidence Interval |
| CMD | Craniomandibular disorders |
| Co | Condylion |
| Co-Go | Condylion - Gonion |
| Co-Me | Condylion - Menton |
| CT | Computed Tomography |
| $CV^S$ | Caphalometric Variable for the subjects |
| $CV^{STD}$ | Caphalometric Variable for the standard population |
| d | Difference between the first and second recordings |
| DD | Disc Displacement |
| DL | Disc Length |
| EMS | Residual source of variation |
| F | F-statistic |
| FDD | Full disc displacement |
| FDDM | Full disc displacement with severe loss of morphology |
| FH | Frankfort Horizontal |
| FH/Ar-Go | Frankfort horizontal/ Articulare - Gonion |
| FH/Co-Or | Frankfort horizontal/ Condylion - Orbitale |
| FH/Go-Me | Frankfort horizontal/ Gonion - Menton |
| FID | Free Induction Decay |
| gms | Grams |
| $gms/mm^2$ | Grams per square millimeter |

| | |
|---|---|
| Gn | Gnathion |
| Go | Gonion |
| Go-Me | Gonion - Menton |
| i.e. | That is |
| ICC | Intraclass Correlation Coefficients |
| IGF I | Insulin Like Growth Factor I |
| IgG | Immunoglobulin G |
| IL | Illinois |
| Inc. | Incorporated |
| JMS | Source of variation between observers |
| k | Number of observers |
| *k* | Number of categories |
| *k*/SE | Z statistic |
| L TMJ | Left Temporomandibular Joint |
| LI | Lower incisor |
| LI/Go-Me | Lower incisor/ Gonion - Menton |
| LIA | Lower incisor apex |
| LIT | Lower incisor tip |
| LIT/Go-Me | Lower incisor tip perpendicular to Gonion - Menton |
| max | Maximum |
| MDD | Moderate disc displacement |
| Me | Menton |
| MHz | MegaHertz |
| min | Minimum |
| mm | Millimeters |
| MR | Magnetic Resonance |
| MRI | Magnetic Resonance Imaging |
| ms | Milliseconds |

| | |
|---|---|
| n | Number of radiographs traced |
| N | Nasion |
| N | Normal |
| N-ANS | Nasion - Anterior nasal spine |
| N-Me | Nasion - Menton |
| N-S-Ba | Nasion - Sella - Basion |
| NEX | Number of acquisitions |
| NJ | New Jersey |
| OP | Functional occlusal plane |
| Or | Orbitale |
| p | Statistical significance |
| *p* | Number of variables |
| PA | Pennsylvania |
| PCA | Principal component analysis |
| Pg | Pogonion |
| PNS | Posterior nasal spine |
| Po | Porion |
| Ptm | Pterygomaxillary fissure |
| Ptm-ANS | Pterygomaxillary fissure point inferior - Anterior nasal spine |
| R TMJ | Right Temporomandibular Joint |
| $R^2$ | R-square |
| RCP | Retruded contact position |
| Rel | Reliability |
| Rel = 1-1/F | Coefficient of intra-rater reliability |
| S | Sella |
| S-Ar | Sella - Articulare |
| S-Ba | Sella - Basion |

| | |
|---|---|
| S-Co | Sella - Condylion |
| S-Go | Sella - Gonion |
| S.E. | Standard Error |
| S.E.M. | Standard Error of the Mean |
| $S_c$ | Standard deviation of the differences of each of the replicates from the mean |
| SD | Standard deviation |
| SDD | Slight disc displacement |
| $SD^{STD}$ | Standard Deviation of the cephalometric variable for the standard population |
| SEM | Scanning Electon Microscopy |
| SN | Sella-Nasion |
| $S_n$ | Discriminate scores |
| SN | Sella - Nasion |
| SN-PNS | Posterior nasal spine perpendicular to Sella - Nasion |
| SN/ANS-PNS | Sella - Nasion/ Anterior nasal spine - Posterior nasal spine |
| SN/Ar-Go | Sella - Nasion/ Articulare - Gonion |
| SN/Go-Me | Sella - Nasion/ Gonion - Menton |
| T | Tesla |
| $T_1$ | Longitudinal relaxation |
| $T_2$ | Transverse relaxation |
| TE | Echo time |
| TGFβ | Transforming Growth Factor Beta |
| TIMP | Tissue Inhibitors of Metalloproteinases |
| TMD | Temporomandibular joint dysfunction |
| TMJ | Temporomandibular joint |
| TR | Time to Repetition |

| | |
|---|---|
| UI | Upper incisor |
| UI-LI | Upper incisor/ Lower incisor |
| UI/ANS-PNS | Upper Incisor/ Anterior nasal spine - Posterior nasal spine |
| UIA | Upper Incisor Apex |
| UIT | Upper Incisor Tip |
| USA | United States of America |
| $V^2$ | Variable squared |
| $V^3$ | Variable cubed |
| X | Variable |
| Y | Variable |
| Z | Variable |

# CHAPTER 1

## An Introduction to the Study of the Temporomandibular Joint

### 1.1 General Introduction

The human skull is composed of osseous and dental units which articulate with one another in regions of approximation. Some of these articulations are non-mobile fibrous synarthroses or sutures while others in the cranial base region, are cartilaginous. It is at these articulations that remodeling and apposition occur as the osseous units are separated from one another during growth. Later, in adulthood, the sutures are less active but are involved in the continual remodeling and turn-over of bone which occurs with aging.

The temporomandibular joint (TMJ) is the only mobile articulation in the craniofacial region. These form bilateral articulations between the mandibular condyles and temporal bones on the lateral regions of the base of the skull. Interposed between the osseous articular surfaces of each joint is a fibrous articular disc. In the normal, healthy joint the disc remains interposed between the osseous articular surfaces during all movements of the mandible. Occasionally, the disc is displaced and no longer functions between the osseous articular surfaces.

The consequences of disc displacement are numerous and depend on the degree of disc displacement, degree of inflammation, duration of the displacement and joint damage associated with the displacement, as well the adaptive capacity of the individual. Clinical signs and symptoms are associated with disc displacement and occur with mandibular movement. These may be summarized as: preauricular pain; joint sounds; limited mouth opening; deviation of the mandible to the affected side; joint and capsular tenderness; and tenderness of the muscles of mastication. In addition to the clinical symptoms identified, it has been suggested that in the adult population disc displacement may be associated with osteoarthrosis[1]. Further associations between disc displacement, osteoarthrosis, degenerative joint disease and the development of progressive malocclusion in an adult sample has also been suggested[2].

In adolescents, the pioneering work of Dibbets *et al* showed associatons between radiographic alteration of condylar morphology (osteoarthrosis), as viewed on lateral transcranial radiographs (Parma views), and alteration in facial morphology[3,4,5]. In addition, subjective symptoms of TMJ dysfunction were shown to be associated with changes in the position of the mandible relative to the cranial and maxillary structures[4]. Longitudinal evaluation of these individuals over an extensive period showed that the facial alterations persisted into adulthood and rarely increased in severity, indicating that localized growth alterations of the condyle during adolescents may predict future adult facial patterns[6]. These studies drew attention to the association between the TMJ and facial morphology, showing that altered osseous morphology of the condyle is related to altered osseous relationships of the various facial components.

The studies of Dibbets *et al* were, however, unable to visualize the soft tissue articular disc or to suggest whether the articular disc was affected in the process. Therefore, no associations between altered disc position within the TMJ and altered facial morphology in adolescents could be made. Recently, the use of Magnetic resonance imaging (MRI) of the TMJ has made it possible to visualize the articular disc.

Imaging studies have shown disc displacement to occur in adults with a prevalence of approximately 30% in the asymptomatic individual[7,8], and to occur in approximately 82% of individuals presenting with signs and symptoms of craniomandibular disorders or pain[8].

It is generally accepted that adolescent individuals are affected by disc displacement[9-11].

It has been suggested that the localization of pain is less specific in younger individuals[12]. For example, adolescents may complain of stomach symptoms when in fact an ear infection is present. This makes it increasingly difficult to identify and study adolescents with disc displacement of the TMJs. Direct imaging of soft tissue articular structures of the joints, using Magnetic Resonance Imaging (MRI)[8], has greatly enhanced the study of the TMJ and may be of use in understanding the pathophysiology of disc displacement.

The present study is concerned with determining whether associations exist between disc displacement affecting the adolescent population and craniofacial morphology. To better understand the associations between TMJ disorders and craniofacial morphology, normal and abnormal disc position and function will be reviewed. The pathogenesis, pathophysiology and identification of disc displacement will be discussed in order to understand the mechanisms that affect the joint. By making reference to literature pertaining to the TMJ as well as other synovial articulations, the consequences of disc displacement will be investigated. Shortcomings and benefits of various methods used to assess TMJ status will be discussed with specific reference to its application in the adolescent population. The importance of direct assessment of TMJ disc position will be argued in light of available evidence that suggests that an association between abnormal disc position and altered localized growth potential in the developing adolescent joint exists.

The literature agrees that the condylar cartilage is not a primary growth centre but rather an adaptive growth site which contributes to the vertical and sagittal development of the mandible[13]. Numerous studies have concentrated on the condylar contribution to normal growth, while others have investigated factors that may be associated with altered condylar development[14-16]. In order to fully appreciate the diversity of mechanisms responsible for local and generalized growth alterations, localized environmental factors affecting the TMJ will be reviewed.

This review will increase the understanding of TMJ function and dynamics and more specifically, the articular disc. Keeping this in mind and considering the pathophysiology of disc displacement, it should be possible to consider the effects of disc displacement in the TMJ of affected adolescents. Furthermore, alterations in craniofacial morphology associated with disc displacement may be better appreciated.

## 1.2 The Temporomandibular Joint in Health

The temporomandibular joint is classified as a compound joint which, by definition, requires the presence of at least three bones. The condyle and the articular eminence are the functional convex osseous surfaces of the joint, while the biconcave articular disc provides the concave surfaces of the joint, and can be considered as the third bone[17] (Figure 1.1). Each joint provides for hinging movement in one plane, as well as gliding movements. The TMJ is therefore classified as a ginglymoarthrodial joint[18]. Traditionally, hinging movements are considered to take place between the condyle and inferior surface of the articular disc, in the inferior joint space, while gliding movements occur between the superior surface of the disc and the posterior slope of the articular eminence.

The temporomandibular joint is formed by the articulation of the condyle of the mandible with the temporal bone on the base of the skull. The squamous part of the temporal bone contributes most significantly to the formation of the superior portion of the mandibular fossa. The tympanic portion contributes to formation of the posterior wall of the fossa. Anteriorly, the articular eminence arises on the inferior surface of the zygomatic process of the temporal bone[19]. The articular disc is the third articulatory member of the joint, completing the assembly of the joint.

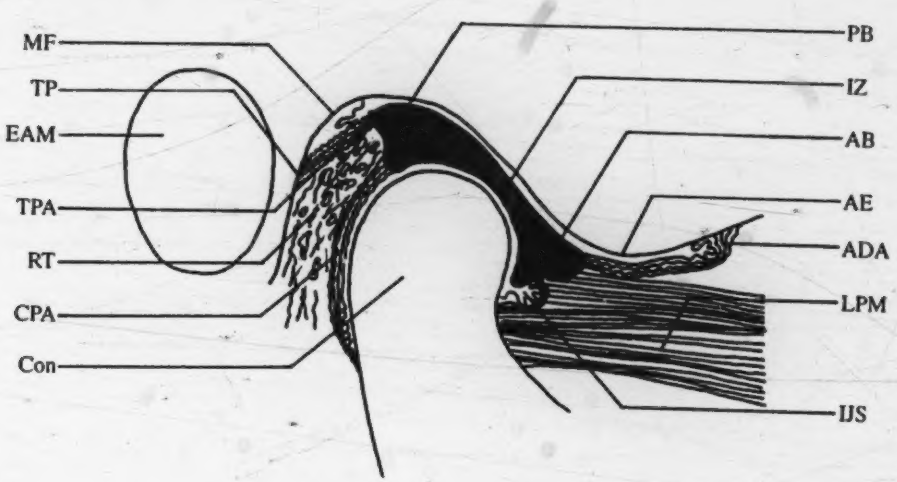

Figure 1.1: Structure of the Temporomandibular Joint

(MF: mandibular fossa; TP: tympanic plate of temporal bone; EAM: external auditory meatus; TPA: temporal posterior attachment; RT: retrodiscal tissues; CPA: condylar posterior attachment; Con: condyle; PB: posterior band; IZ: intermediate zone; AB: anterior band; AE: articular eminence; ADA: anterior discal attachment to temporal bone; LPM: lateral pterygoid muscle; IJS: inferior joint space)

The aim of this review section is to familiarize the reader with the components of the temporomandibular joint. The gross histological structure of each component will be discussed as it relates to joint function. In addition, changes occurring in the joint with growth and maturation will be made evident to the reader. This review will focus on the osseous components of the joint, the articular disc, the synovial membrane, and joint capsule. Thereafter, normal joint function will be reviewed.

### 1.2.1 The Osseous Components

The outer articular surface of the condyle is composed of two layers. Externally the condyle is covered by a fibrocartilaginous articular layer that is maintained by continual turn-over and replacement of cells and matrix produced by chondrocytes within the underlying cartilage, which constitutes the second layer (Figure 1.2). Maintenance of this fibrocartilaginous articular tissue, throughout life and function, is essential for the health of the joint. This articular cartilage consists of two principal phases: a solid organic matrix composed of collagen fibrils and proteoglycan macromolecules, and a movable interstitial fluid phase which is predominantly water[20]. The relative composition of each of the articular layers varies, and is dependent on the localized function of the region.

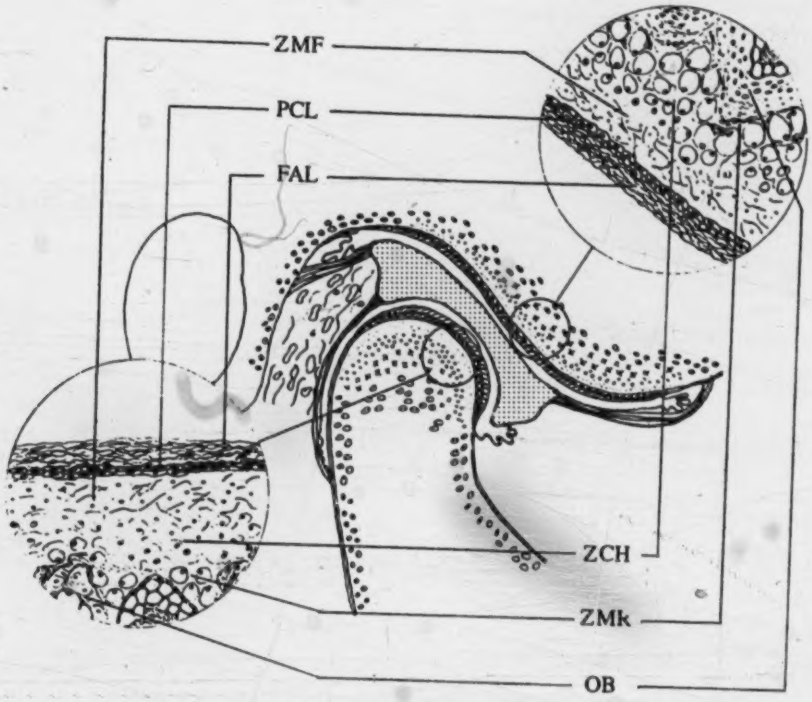

Figure 1.2: Osseous Articular Surfaces of the TMJ

(ZMF: zone of matrix formation; PCL: proliferative cellular layer, FAL: fibrous articular layer, ZCH: zone of cellular hypertrophy; ZMR: zone of mineralization and resorption; OB: osseous bone)

The outer fibrous articular layer is of variable thickness depending on its position within the joint as well as the age of the individual. This layer consists of collagen fibers with a predominantly sagittal orientation[21], although more recently a three-dimensional network of the collagen fibrils has been displayed with SEM[22]. Some fibrocytes but no chondrocytes are evident in this layer[14]. Beyond the boundaries of the inferior joint space the fibrous articular layer is continuous with the outer fibrous layer of periosteum covering the neck of the condyle.

Subjacent to the articular tissue is the second layer, a cellular proliferative layer about six to ten cells thick. Although proliferative in nature, mitoses are not apparent. Beyond the margins of the underlying cartilage, the proliferative layer becomes continuous with the inner or osteogenic layer of the periosteum. In the adult the periosteum rests on cortical bone which in turn is supported by radially oriented trabeculae. The cortical bone is absent in the growing adolescent and in its place is a layer of cartilage consisting of three distinct regions: a region of matrix formation, cellular hypertrophy and mineralization. Beneath this tissue is an area of resorption and cartilage replacement by mineralized osseous trabeculae[23].

The structure of the posterior articular surface of the articular eminence is essentially identical to the surface of the condyle. Both structures arise from secondary cartilage and are covered with fibrocartilage of varying thickness[23]. In the adult the fibrocartilage is thickest (0.45 mm) in the postero-inferior region of the slope of the articular eminence and thinnest (0.07 mm) in the roof of the fossa[24]. The fibrocartilage of both the condyle and articular eminence is free of direct innervation or blood vascular supply. Therefore no pain can be perceived directly from this articular layer and all nourishment is provided by the synovial fluid which bathes the surfaces[25].

### 1.2.2 The Articular Disc

The articular disc is a biconcave structure closely approximated to the head of the condyle. The articular regions of the articular disc are composed of dense fibrous connective tissue (Type I collagen) with specific collagen orientations in various regions of the disc. For descriptive and functional purposes the disc is divided into three articular regions, namely, the posterior band, intermediate zone and anterior band[26,27] (Figure 1.3). Three-dimensionally, the articular disc can be seen as a ring sometimes used by people who carry heavy objects on their heads, with the anterior and posterior bands forming the cushioning which makes it adaptive for weight bearing[28].

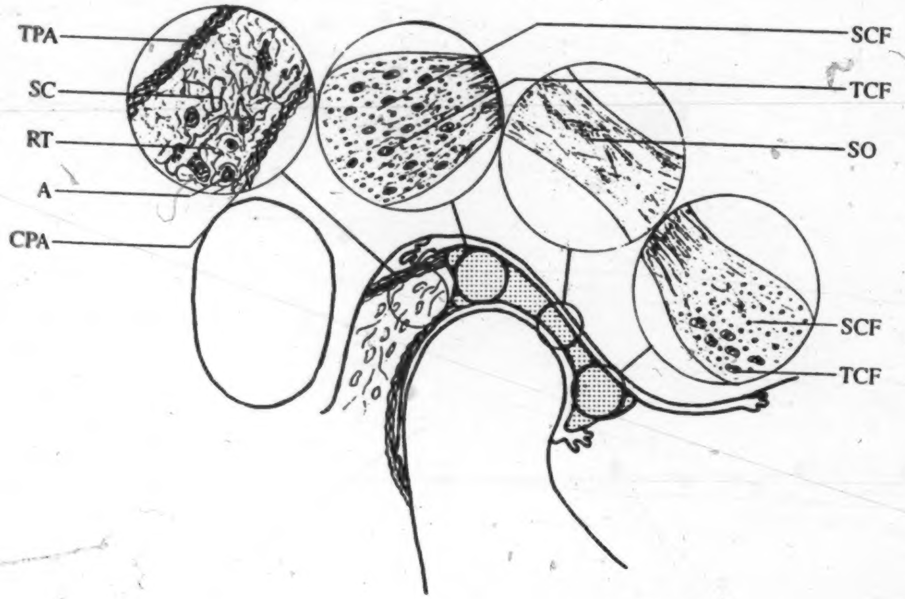

Figure 1.3: Structure of the Articular Disc

(A: retrodiscal tissues and posterior attachments; B: posterior band of the disc; C: intermediate zone; D: anterior band of the disc; TPA: temporal posterior attachment; SC: sinusoidal capillaries; RT: branching reticular tissue in retrodiscal region; A: arteriole; SCF: sagittal collagen fiber arrangement; TCF: transverse collagen fiber arrangement; SO: sagittal and oblique fiber arrangement)

The intermediate zone of the disc is the thinnest region (1.08 mm)[24], consisting of collagen fibers with a sagittal orientation. These fibers have a sagittal orientation, parallel to the osseous articular surfaces which are just superior and inferior to this region of the disc. The intermediate zone is the load-bearing region of the disc and is directly interposed between the condyle and the posterior surface of the articular eminence. Collagen fibers in the intermediate zone fan out medio-laterally as they enter the anterior and posterior band regions of the disc [26,27]. Histochemical evaluation of load-bearing and nonload-bearing regions of the disc indicate that the central load-bearing areas of the disc have a higher concentration of highly sulphated glycosaminoglycans, mainly chondroitin-6-sulphate, evenly distributed in a medio-lateral direction[29]. Also present in these central regions is dermatan sulphate and keratan sulphate, most frequently having a superficial surface distribution[29].

The posterior band of the disc is a thickened region (2.90 mm)[24], located superior to the head of the condyle and filling the anterior portion of the mandibular fossa. This articular region of the disc contains collagen fibers with essentially a transverse medio-lateral orientation. The anterior band of the disc has a similar morphology and structural arrangement to the posterior band but is thinner (2.50 mm). This region of the disc fills the anterior recess between the condyle and posterior slope of the eminence.

The articular disc is closely attached to the head of the condyle by dense collagenous non-articular medial and lateral collateral ligaments. These ligaments insert into the medial and lateral poles of the condyle, respectively and coordinate the range of anterior and posterior rotational movements of the disc and the condyle. Lateral and medial movement of the disc relative to the condyle is also restricted by these ligamental attachments[25].

Posterior to the disc are the non-articular retrodiscal tissues which are composed of loose connective tissue, blood vessels, nerves, fat and discal attachments. The posterior discal attachments are made up of superior and inferior bands described as the bilaminar zone. The superior collagen and elastic fibers originate from the superior margin of the posterior band and attach to the temporal component of the joint along the squamotympanic fissure and postglenoid process. The inferior attachment arises from the inferior margin of the posterior band of the disc and gains attachment to the posterior surface of the neck of the condyle. The highly innervated and vascularized retrodiscal tissue is housed between these discal attachments[26,27].

The inferior attachment of the bilaminar zone has a function similar to the collateral ligaments, namely to act as a guide-wire for functional movements. This attachment ensures coordinated posterior movement of the disc with the condyle as the condyle rotates posteriorly from mouth opening. The superior attachment of the disc was thought to control the posterior movement of the disc from mouth opening by the elastic fibers balancing the anteriorly directed muscle forces during the closing phase of mastication[30,31]. This is no longer considered to be the primary role of this tissue[27]. Instead it is speculated that the elastic fibers branch three-dimensionally and penetrate into thin-walled veins. This intimate association between elastic fibers and walls of veins suggests an association with venous blood flow. The elastic fibers may be responsible for drawing open the lumina of the sinusoidal, thin-walled, anastomatic plexus of blood vessels as the mouth is opened and superior and inferior attachments are separated. Elastic tissue may also act as a pump, pushing blood out of vessels during mouth closure[27].

The anterior attachment of the disc has a temporal superior attachment and a condylar inferior attachment which is complicated by the attachment of the superior head of the lateral pterygoid muscle to the fovea on the antero-medial aspect of the neck of the condyle. Superior to the inferior head of the lateral pterygoid muscle the inferior discal attachments insert onto the anterior region of the condylar neck. The superior discal attachment extends anteriorly to attach beyond the functional articular surface at the height of the articular eminence. Fibers of the superior head of the lateral pterygoid muscle are variable in their attachment to the anterior band of the disc, with some studies reporting attachment[32] while others refute attachment[33].

### 1.2.3 The Synovial Membrane

The previously described attachments of the disc form the boundaries of the joint. It is within these boundaries that the articular cavity is found which contains the articular disc and synovial fluid. The disc divides the articular cavity into superior and inferior joint space compartments which are not in direct communication. The non-articular surfaces of the joint are lined by synovial membrane which provides synovial fluid to the joint compartments. The articular disc is covered by synovial membrane only on its peripheries and attachments. Its lining cells are regarded as a variety of mesothelial cells even though they do not form a continuous layer joined by cell junctions[34]. The synovial membrane comprises a lining layer of cells adjacent to the joint space, called the synovial intima, and a supportive or backing layer called the subsynovial tissue or subintimal tissue[34]. The subintimal tissue merges with the fibrous capsule of the joint onto which it backs[34].

It would appear that synovial cells are normally shed from the intimal surface and that they are replaced by proliferation of cells in the subintimal tissue. The synovial intima contains cells that are about four to six cell layers deep, comprising polygonal-shaped cells or spindle-shaped cells set in a matrix of collagen fibrils and amorphous material[34]. The synovial intimal cells form a compact, discontinuous layer with spaces or gaps between the intimal cells. Nerve fibers are not a feature of the synovial membrane, the only nerve fibers present are autonomic to the adventitia of blood vessels[34]. The synovial membrane is richly supplied with blood vessels and lymphatics. The subintimal tissue consists of collagen fibrils, interfibrillar matrix, fibroblasts, macrophages and mast cells and is richly supplied with sinusoidal or fenestrated capillaries which facilitate the rapid exchange of water and solutes.

The functions of the synovial membrane include production of synovial fluid and removal of synovial fluid and debris from the joint space. The synovial fluid is essentially a transudate from the blood to which is added hyaluronic acid and proteoglycans produced by the synovial cells and some proteins presumably synthesized by synovial cells[35]. However, most of the protein found in synovial fluid is derived from blood by simple diffusion[36].

In addition to a secretory function, the synovial membrane has an absorptive function. The secretion of synovial fluid cannot continue indefinitely in a finite cavity such as the joint space without a corresponding removal of material. The uptake of fluid from the joint space takes place through the intimal cells, as well as an egress of material from the joint space via the gaps between the synovial intimal cells. The presence of numerous lymphatics and fenestrated capillaries facilitates exchange of material to and from the joint space. Larger proteins and joint debris are phagocytosed by intimal cells and subintimal macrophages. Some intimal cells are able to migrate to the deeper subintimal layers to deposit phagocytosed proteins[37]. Thus, at least some of the subintimal macrophages are modified migratory synovial intimal cells.

### 1.2.4 The Capsule

External to the attachments of the disc to the osseous elements of the joint, thickened bundles of collagen fibers with a regular arrangement constitute the capsule of the joint. The capsular attachments have been described as being 7 mm inferior from the highest point on the condyle anteriorly and about 9 mm inferior from the superior aspect of the condyle posteriorly. The medial attachment is at or caudal to the medial pole of the condyle while the lateral attachment is directly on the lateral pole of the condyle[38,39].

Lateral to the joint, the capsule consists of strong collagen fibers running from their attachment on the inferior surface of the temporal bone to the neck of the mandible with no elastic fibers evident in association with the collagen fibers. Collagen fibers of the articular disc insert into the lateral wall of the capsule. This lateral thickening of the joint constitutes the lateral temporomandibular ligament.

Medial to the joint, superior and inferior attachments of the articular disc occur to the temporal bone and condyle respectively. These attachments are continuous from the posterior to the anterior joint regions and demarcate the superior and inferior joint spaces. No collagen fibers connect the temporal bone directly to the medial side of the mandible as evidenced in the lateral region of the joint[32].

Blood supply to the joint is to a large degree an extension of the capsular plexus[40]. The capsular plexus is formed from multiple branching vessels which arise form the maxillary, superficial temporal and middle meningeal arteries[40]. The thickened lateral portion of the capsule may appear less vascular than the remainder of the capsule but is far from avascular. Vessels are most conspicuous in the retrodiscal region of the joint and the antero-medial prearticular space[26].

The medial portion of the joint is also richly supplied with vessels[40]. The entire capsular region is surrounded by a rich vascular plexus which supplies the structures of the temporomandibular joint.

The capsule is innervated by branches of the trigeminal nerve. Large nerve bundles are seen in the pericapsular connective tissue anterior and posterior to the joint. Nerves branch from these large nerves, travel with blood vessels to the anterior and posterior bands of the disc and terminate as nerve endings in the discal attachments[41,42]. Receptor-like structures have been identified in the pericapsular connective tissue and in the peripheral disc. These structures are non-encapsulated pain-endings connected to lightly myelinated fibers and an array of encapsulated receptors connected to myelinated nerves which respond to mechanical and proprioceptive stimuli.

The concentration of neural receptors is greatest at the anterior and posterior margins of the disc, with the greatest concentration posteriorly. The population density is greatest at the periphery of the disc and progressively decreases towards the centre, which is devoid of neural elements[42]. It appears that the presence of nerves in discal attachments indicates that its status is monitored by the central nervous system. Similarly the capsular elements may play an important role in reflex control of the mandibular musculature and hence joint function.

### 1.2.5 Normal Joint Function

The condyle approximates the posterior surface of the articular eminence with the intermediate zone of the disc interposed when the joint is at rest and the teeth are in contact. As the depressor muscles contract and gravity allows the mandible to drop downwards, rotation occurs between the condyle and the inferior surface of the disc. This rotation is controlled by the coordinated contraction of antagonistic elevator muscles of mastication and ligaments which keep the condyle in close approximation with the articular eminence[43]. Further mouth opening produces increased rotation in the inferior joint compartment and translation between the superior surface of the disc and the posterior surface of the articular eminence. The controlled contraction and the ligamentous effects results in close apposition of the osseous articular surfaces of the joint during mouth opening[44]. During mouth closure the elevator muscles contract and the reverse movements occur in the respective joint compartments. As with mouth opening, a resultant compressive force is applied to the disc interposed between the articular surfaces[43].

During mastication, when a bolus is introduced between the dentition and force is applied to the bolus, an increased force is experienced by the joint structures[45,46]. Throughout these movements the function of the disc is to[34]:

- act as a shock-absorber and load distributor,
- maintain joint stability,
- aid in joint lubrication by spreading synovial fluid on the articular surfaces, and

- act as a mechanical device which permits rotary motion to occur in the joint.

Those disc functions which are of particular interest include the disc's ability to dissipate masticatory loads and provide lubrication for the joint surfaces. These functions are accomplished as a result of the arrangement of hydrophilic proteoglycans, hyaluronic acid, tissue fluids, and collagen within the disc and articular cartilages.

The collagen arrangement forms a framework in which long chain hyaluronic acid molecules are trapped. Proteoglycans are attached to the long chain hyaluronic acids to produce aggregate proteoglycans. Glycosaminoglycans contain a high concentration of fixed, negatively charged groups which allows this tissue to attract counterions in the interstitial fluid. As a result, the tissue has a high capacity to swell and gain or lose water under varying mechanical environments. At equilibrium, this swelling force is balanced by the tensile strength of the surrounding collagen matrix. Consequently, even in an unloaded state, the *in situ* collagen network of articular cartilage is under tensile pre-stress[47]. This lends rigidity and turgor to the discal tissue and permits it to act as a shock-absorber.

Tensile resistance is provided by the collagen network, compressive resistance by the glycosaminoglycans and diffusion resistance is generated as the fluid flows through the matrix[20].

As pressure is applied to the disc during mastication, fluid is released from within the disc and squeezed into the joint space between the loaded osseous surfaces and the disc in a process termed weeping lubrication[48]. The fluid forms a layer thin enough to continually separate the opposing surfaces and provide joint lubrication. The fact that the discal tissues are thicker than the fibrocartilage covering the condyle or articular eminence implies that the disc may be the primary source of weeping lubrication[24,48].

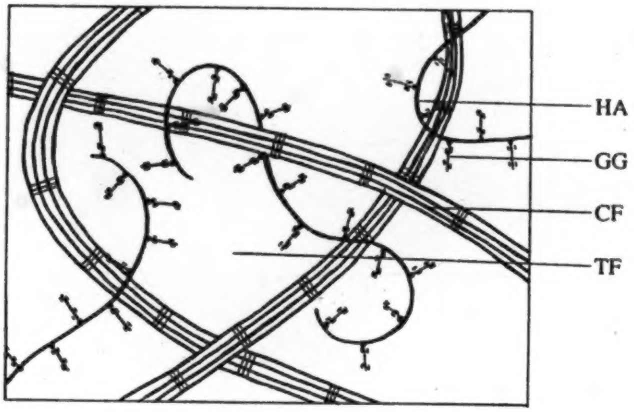

Figure 1.4: Arrangement of Collagen and Proteoglycans in the Articular Disc
(HA: hyaluronic acid chains; GG: glycosaminoglycans; CF: collagen fibrils: TF: tissue fluid; HA + GG = proteoglycans)

An additional benefit of fluid movement from the disc during application of pressure is the movement of fluid, under pressure, into the fibroarticular surface of the condyle and posterior surface of the articular eminence[49]. This fluid transport ensures hydration and a supply of high molecular weight nutrients to the fibrocartilage which is also supplied by simple diffusion[49,50]. As the fluid enters the fibrocartilage[49], surfactants such as glycoproteins and phospholipids dissolved in the fluid are not permitted to diffuse through the surface layer of cartilage due to their molecular size and are deposited on the surfaces instead. The deposited viscous gel separates the surfaces and forms a boundary lubricant, providing a second form of lubrication[51-53]. A third source of lubrication is the constant supply of synovial fluid produced by the synovial membrane.

The unique position and function of the articular disc within the TMJ therefore allows for force distribution, lubrication of joint surfaces and perfusion of the avascular fibrocartilage covering the osseous articular components of the joint. It should be noted that normal pressure application during function is essential for the maintenance of the articular tissues and that normal disc position is necessary to ensure that the tissues of the joint are adequately hydrated[48]. In a normal joint, pressures applied to the articular surfaces of the joint are well tolerated. More importantly, when the disc is interposed and functioning during health, the pressure is essential to maintain the integrity joint structures and provide nutrients for continual repair and remodeling.

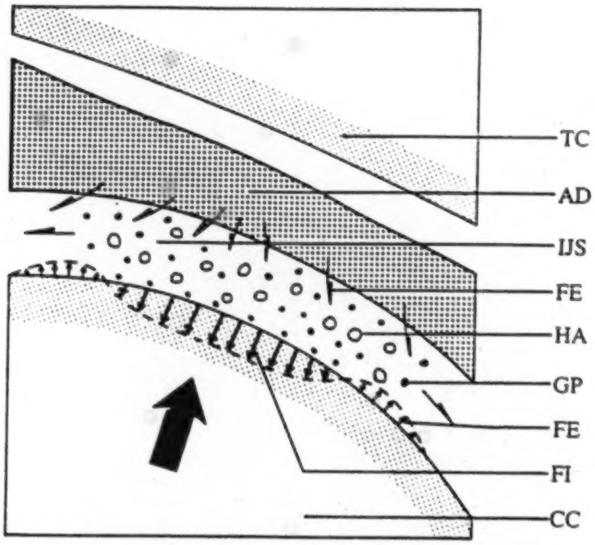

Figure 1.5: Mechanisms of Joint Lubrication under Load

(TC: temporal cartilage; AD: articular disc; IJS: inferior joint space; FE: fluid efflux out of disc and articular cartilage; HA: hyaluronic acid; GP: glycoproteins; FI: fluid influx under pressure; CC: condylar cartilage)

## 1.3 Condylar Morphology and Contribution to Facial Development

The role of condylar cartilage in development of the mandible and its contribution to establishing facial balance will be evaluated. The origin of the tissues constituting the temporomandibular joint region is discussed and the histology of the condylar cartilage described. The development of the condyle from birth to adolescence and subsequent changes that take place once maturity is reached will also be described. The contribution of the condyle to mandibular development needs to be placed in perspective relative to the other regions which contribute to development of the mandible. In addition an overview of the mechanisms involved in stimulating condylar development is necessary in order to evaluate the role of condylar cartilage in facial development.

### 1.3.1 Origin of the Condyle

The embryonic temporomandibular joint arises from the condylar and temporal blastemas, which develop separately, both in time and space. The initial absence of temporal structures differentiate the development of this joint from other joints that form between two bones which are in contact during development. In time the temporomandibular joint components are approximated by enlargement of the condyle as it extends dorsally and cranially to meet the temporal component.

The temporomandibular joint is termed a "secondary joint". The term "secondary" refers to several separate properties of the joint that differentiate it from a "primary joint." These distinguishing characteristics are[54]:

- Phylogenetically and embryologically the temporomandibular joint represents a secondary joint replacing the older articulation between the articulare (malleus) and the quadrate (incus) in higher reptiles[55]. In mammals these osseous structures are incorporated into the middle ear and a new joint develops between the dentary (developing mandible) and temporal bone,
- The temporomandibular joint forms relatively late during embryological development (8th week intra-uterine) compared to all other joints in the axial and appendicular skeleton (5th week intra-uterine). This makes the temporomandibular joint one of the last joints in the body to develop. "Secondary" may therefore refer to the late ontogenetic development of the joint,
- The condyle and temporal components of the joint are covered by secondary cartilage. This cartilage is termed secondary cartilage since it appears on bone surfaces which are lined by periosteum and formed by intramembranous ossification. The secondary cartilage arises from undifferentiated mesenchymal cells that eventually cap the

postero-superior region of the developing intramembranous mandibular bone. The mesenchymal cells covering the external surface of the developing intramembranous bone in the joint region are modified due to their functional environment. Mesenchymal tissue subjected to functional loading, ischemia and anoxia are induced to undergo chondrogenesis with cartilage formation, rather than osteogenesis which would normally occur on periosteal surfaces[56], and

- Primary epiphyseal cartilage reacts during development primarily to overall systemic growth stimuli such as hormones. In contrast, condylar cartilage only secondarily follows these overall stimuli after additional modulation by local factors. "Secondary" may apply to the characteristic response of the condyle during growth.

Meikle[57] considers the secondary cartilage of the condyle to be derived from periosteum. Periosteum in the articular region changes from its normal osteogenic role to one of chondrogenesis as a consequence of altered functional requirements. Murray[58] showed in experimental animals that mobile articulations stimulate cartilage formation. Muscle attachments that are able to set up areas of strain have a similar effect. In paralysed joints, bone is produced instead of cartilage. It was further noted that osteogenesis or chondrogenesis may be evoked in a tissue depending on the degree of vascularity of the tissues and the presence or absence of mechanical stress on the tissue[56]. In vitro, hypoxia enhances osteogenesis and anoxia enhances chondrogenesis. Hall[56] suggests that mechanical stresses may act by producing ischemia, thereby inducing osteogenic cells of periosteum in regions of articulation to undergo chondrogenesis.

### 1.3.2 Condylar Histology

The condyle is one of three regions of secondary cartilage formed due to functional demands on the surface of the developing mandible. In lower vertebrates, angular cartilage is found at the angle of the mandible between the union of the body and ramus. This cartilage proliferates in response to tension induced by masseter action. The tendinous attachment of the temporalis muscle inserts into the antero-superior surface of the ramus and is thought to influence the formation of secondary cartilage in the coronoid process. Separated from the coronoid process by the mandibular notch, the condylar cartilage develops on the postero-superior surface of the ramus in response to the articular demands of the mandible.

The superior aspect of the condyle is covered by secondary cartilage responsible for regional adaptive growth. This cartilage maintains the condylar region in proper anatomic relationship with the temporal bone as the whole mandible is simultaneously carried downward and forward with growth. Secondary condylar cartilage is composed of three distinct layers[59]:

1. An outer densely fibrous articular layer of even thickness except where there is articular contact between the condyle and articular eminence (Figure 1.6). Here it is thinner and appears compressed. This layer consists of collagen fiber bundles with a predominantly antero-posterior orientation, some fibrocytes but no chondrocytes[21]. More recent Scanning Electron Microscopic evaluations reveal a more three-dimensional network without a specific sagittal orientation of the collagen fibrils[22]. Beyond the boundaries of the inferior joint space the fibrous articular layer is continuous with an outer fibrous layer of periosteum covering the neck of the condyle.

2. Subjacent to the articular tissue is a cellular proliferative layer of prechondroblast cells. Although proliferative in nature, mitoses are not apparent. Followed beyond the margins of the underlying cartilage, the proliferative layer becomes continuous with the inner or osteogenic layer of the periosteum. According to Ingerval *et al*[60], the proliferative cell layer shows equal activity and thickness from birth to approximately 13 to 15 years.

3. The third and innermost layer of tissue covering the condyle contributes to

continuous cartilage replacement for endochondral ossification. This region of cartilage formation can be divided into three zones: an outer zone of matrix formation, a middle zone characterized by cellular hypertrophy, and an inner zone of calcification and resorption.

3.1 The zone of matrix formation is characterized by scanty matrix synthesis (when compared to hyaline cartilage). Here chondrocytes are progressively displaced from one another as they approach the zone of cellular hypertrophy.

3.2 In the zone of cellular hypertrophy, the chondrocytes become expanded, the cytoplasm is vacuolated, but each cell remains enclosed in its separate lacuna.

3.3 The innermost zone of cartilage shows mineralization of the matrix. On its deep surface the matrix becomes resorbed and bone deposition occurs around remnants of the cartilage.

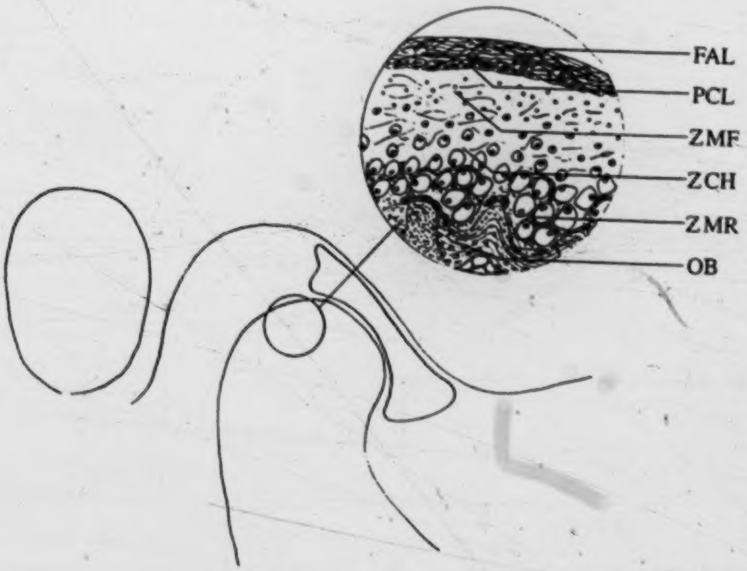

Figure 1.6: Histological Structure of Condylar Cartilage

(FAL: fibrous articular layer; PCL: proliferative cellular layer; ZMF: zone of matrix formation; ZCH: zone of cellular hypertrophy; ZMR: zone of cartilage mineralization and resorption; OB: osseous bone formation)

Endochondral bone formation replaces the forming cartilage at the resorptive interface between the developing cartilage and the formed bone. The newly formed bone contributes to the formation of the neck of the condyle. This endochondral bone contributes to the enlargement of the ramus which develops by intramembranous ossification. In time the endochondral bone of the condylar neck is remodeled and incorporated into the ramus as it enlarges.

### 1.3.3 Condylar Development

At birth, the temporomandibular joint is relatively small and flat. The condyle measures approximately 5 mm antero-posteriorly and 9 mm medio-laterally and is essentially a growth cartilage. As facial growth proceeds the condyle grows in size and enlarges in a posterior, lateral and superior direction[19]. In addition to its growth contribution, it assumes the role of an articular cartilage as mandibular movements become more coordinated and complex. Between 5 and 10 years of age it measures about 9 x 15 mm and by the age of 20 years the condyle is approximately 10 x 20 mm. By adulthood growth activity has diminished and the role of condylar cartilage is limited to maintenance turnover. Finally the cartilage functions almost entirely as an articular cartilage but never ossifies or disappears completely[13].

The internal osseous components of the developing condyle are well vascularized at birth and give rise to vertical vascularized strands of connective tissue which penetrate the relatively avascular cartilage[23]. These vascular channels, or crampons, persist in the cartilage beneath the fibrous articular layer from birth to the age of 6 years. As these vascular channels reduce there is decreased blood supply to the cartilage and an associated 50% decrease in the thickness of the cartilage[61,62]. Consequently, at birth the cartilage layer is 1.5 mm thick but decreases to 0.5 mm in the first 6 months of life, and to 0.3 mm in adulthood[61]. As growth proceeds the vascular channels are totally obliterated and cartilage relies on diffusion and pumping mechanisms to supply nutrients. It is speculated that cartilage thickness decreases in response to the decreased perfusion and reliance on diffusion and active pumping of metabolites for maintenance[50].

The mixed dentition period, 6 to 12 years of age sees a gradual increase in all dimensions of the condyle with a shortening of the antero-posterior dimension of the growth cartilage[23]. The condylar cartilage gradually becomes orientated more anteriorly and assumes a semilunar profile adjacent to the posterior slope of the articular eminence and the intervening disc[23]. This anteriorly directed cartilaginous growth in combination with bone resorption on the anterior border of the neck of the condyle results in an antero-posterior projection of the condyle. The primary trabeculae are seen to be orientated in the direction of chondrogenesis. The condyle continues to grow laterally as evidenced by periosteal deposition on its lateral cortex and endosteal deposition on its medial cortex[23]. As a consequence of this regional mineralized bone deposition and resorption, the condyle becomes relocated in a postero-lateral and superior direction[23].

By the age of 12 years the entire peripheral superior surface of the condyle consists of calcified cartilage. No increase in thickness of growth cartilage corresponding with the pubertal growth spurt is observed. During the teenage period, an outer superficial bony layer forms through confluence of the most superficial trabeculae[60]. At the age of 16 to 17 years the margins of growth cartilage rest upon a thin surrounding sleeve of bone which encloses the bony trabeculae and their cores of calcified cartilage[60,63]. A subarticular plate of bone closes off medullary spaces. At 20 or 30 years of age the cartilage is almost completely replaced by endochondral ossification and remnants of calcified cartilage in the bony plate and underlying trabeculae gradually disappear as internal remodeling continues[23,63].

In the young adult there is noticeable thickening of the outer osseous margins of the joint components which marks the completion of the active condylar growth period[60]. An irregular and often thin layer of mineralized cartilage is evident in several areas of the surface of the joint components in adults. It should be emphasized that no calcification takes place in either the temporal or condylar undifferentiated cellular proliferative layer or fibrous linings[60]. These tissues are maintained throughout life and provide continual remodeling and replacement of damaged and worn articular tissue.

The condyle undergoes alterations in morphology throughout the period of active growth and development. There are alterations in tissue thickness, tissue constituents and the degree of calcification. It should be stressed that the condyle undergoes continual change throughout life and these changes appear to be related to changes in mandibular function, occlusion and increasing age. Age-related bone loss may not result from decreased bone formation but rather an imbalance between bone formation and resorption.

In conclusion, it is important to stress that a detailed histologic and morphologic description of condylar cartilage, no matter how exhaustive, is not synonymous with an explanation of the growth process of the cartilage. It should be kept in mind that the condyle does not control the growth of the entire mandible but is nevertheless essential for normal mandibular development, particularly the enlargement of the ramus[57]. In this regard, loss of normal histological architecture, condylar cartilage growth potential and contribution to ramal development may produce compensatory adaptations in other adaptive craniofacial regions resulting in distinct patterns of craniofacial adaptation.

### 1.3.4 Condylar Contribution To Facial Development

It has been emphasized that the condyle is a unique region contributing to mandibular development. The condyle develops from mesenchymal cells and contributes to mandibular growth through a process of endochondral ossification. Other regions of endochondral ossification are also incorporated into the mandible but generally disappear within the first few years of life, whereas the condylar cartilage remains present throughout life.

However what is not emphasized is the fact that the condyle is merely another growth region of the mandible[59]. All growth regions of the mandible, such as the ramus, coronoid process, condyle and corpus of the mandible contribute to the overall shape and size of the mandible[59]. Therefore each region which contributes to the growth and remodeling of the mandible should be viewed as a growth field[59] which is locally important in modulating the amount, direction and timing of its own regional growth responses in relation to the ongoing and widespread changes in the surrounding craniofacial regions.

The condyle should not be viewed as a growth centre but rather as a growth site or localized growth field. The major differences between the interpreted "growth centre" versus a "growth site" are discussed here[64,65].

- Growth centres, typically the epiphyseal growth plates, have been considered to have intrinsic genetic potential for cartilage proliferation and growth. Growth sites are considered to have lesser genetic control over growth processes while environmental factors have a greater influence in modulating growth in these regions. Condylar cartilage is classified as a growth site which has intrinsic genetic growth potential, but this genetic potential is restricted to the capacity for continued cellular proliferation. That is, condylar cartilage is coded to divide and continue to divide, but extracondylar environmental factors are needed to sustain this activity.
- Growth centres and growth sites both respond to hormonal growth signals from androgens and growth hormone. Growth centres are stimulated to a mature end point of osseous fusion over the cartilaginous growth plate from which point no further growth can occur. Growth sites, however, remain receptive to hormonal stimulation throughout life and may respond with further growth even when active growth is complete.
- Growth centres such as epiphyseal plates are capable of generating tissue separating forces in the region of 9.5 gms/mm$^2$. Growth sites cannot generate sufficient force to produce tissue separation, e.g. condylar cartilage produces only 2.6 gms/mm$^2$ of tissue

separating force while synchondroses produce even less tissue separating force (1.5 gms/mm$^2$)[13]. Experiments designed to test the role of nasal cartilage have been equivocal, and its clear-cut designation as a growth centre, growth site, or something in between, has not been possible[65].

- Growth centres produce columns of proliferating cells which divide by mitosis, producing interstitial expansion and growth of cartilage. By contrast, proliferating cells in growth sites add to the cartilage mass by appositional external surface cartilage additions. Noteably, both forms of cartilage do however enlarge by cartilage hypertrophy.
- Histologically, growth centres have highly organized columns of cells with a large extracellular matrix component. Many of the cells in the cell stacks or columns undergo division through mitosis. Growth sites are more cellular, with scanty extracellular matrix and few mitotic figures mostly in close contact with the undifferentiated cellular proliferative layer.

In order to evaluate the contribution of the condyle to development of the mandible it is necessary to review the contribution of the various growth regions or fields at a local level as well as the overall contribution that occurs with displacement and remodeling. For descriptive purposes the mandible can be divided into six growth fields, these should not be viewed as separate entities with rigid borders without overlap. Instead, growth in one region may influence growth or remodeling in another which ultimately gives rise to the distinct shape and size of the mandible.

### 1.3.4.1 Ramus

The ramus joins the body of the mandible (corpus) at the mandibular angle in the region of the lingual tuberosity. Superiorly, the ramus unites with the posteriorly positioned condyle and the anteriorly placed coronoid process. Bilaterally, the rami bridge the sagittal gap between the condyles, which articulate with the temporal bones posteriorly, and the corpus of the mandible, which articulates with the maxillary dentition anteriorly.

In addition, the rami form the lateral osseous boundaries of the centrally situated oropharynx.

The growth response of the ramus is largely part of the growth response of the craniofacial complex. The craniofacial regions respond to muscle tension, periosteal apposition and resorption, cartilage proliferation, neural and vascular tissue enlargement, tongue function and increased functional needs of the airway[59,66,67]. The nasomaxillary complex is displaced downwards and forwards by an as yet undetermined combination of mechanisms that allows for enlargement of the nasal airways. Inferior to the maxilla the mandible articulates with the maxilla through approximation of the dentition. A displacement of the maxilla therefore necessitates a displacement of the mandible so that harmonious dental contacts may be maintained. As this occurs the space between the middle cranial fossa and the corpus of the mandible increases in sagittal dimensions, necessitating enlargement of the mandible to maintain the articulation between the condyle and temporal bone on the cranial base. One of the regions responding to this stimulus is the ramus.

The ramus fills the gap and enlarges by apposition of periosteal bone on its posterior surface. At the same time periosteal resorption occurs on its anterior surface permitting drift of the ramus in a posterior direction. This remodeling effect of the ramus has three immediate benefits. Relocation of the ramus bridges the gap between the anterior and posterior articulations of the mandible, the patency of the developing airway is maintained by increasing the sagittal dimensions of the oropharynx while remodeling of the anterior surface of the ramus allows osseous tissue, which was once ramal tissue, to be incorporated into the developing corpus. In this way, ramus is converted to corpus for future tooth eruption and articulation with opposing dentition[59].

Deposition of bone on most of the external surface of the ramus and resorption on the internal surface allows the ramus to be relocated in a transverse direction. This enables the ramus to keep pace with the transverse expansion of the middle cranial fossa and provides space for the developing oropharyngeal airway. In addition to the sagittal and transverse development of the ramus described, vertical development of the ramus takes place due to periosteal surface deposition of bone on its superior border between the condyle and coronoid process.

During the process of growth, the ramus normally uprights. This is accomplished by greater amounts of bone addition on the inferior part of the posterior border of the ramus than on the superior part[59]. A corrrespondingly greater amount of resorption of the anterior border takes place in the inferior part than in the superior part. This produces a rotational effect on the ramus as it uprights from its former inclination. Vertical lengthening of the ramus continues to take place after horizontal ramus growth slows or ceases. This is to match the continued vertical growth of the midface. To achieve this, condylar growth may become more vertically directed, and a different pattern of ramus remodeling occurs[59] (Figure 1.7).

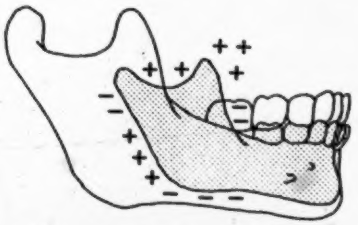

Figure 1.7: Deposition and Resorption Contributing to Ramal and Mandibular Enlargement

( Modified from Enlow DW. Facial Growth 3rd Edition. Philadelphia,WB Saunders Co. 1990,p 109)
(+: indication of periosteal bone deposition and direction of bone growth; -: indication of bone resorption)

### 1.3.4.2 Condylar Process

Nasomaxillary adjustment takes place in an inferior and anterior direction as a consequence of growth displacement[59]. A component of this displacement is matched by ramal remodeling to position the mandible in harmony with the maxilla. The remainder of this displacement is compensated by condylar enlargement.

The condyle grows in a antero-superior direction to establish and maintain articular contact with the temporal component of the articulation. New cartilage is formed on the antero-superior surface of the condyle by appositional growth which allows the previously formed osseous structures of the condylar head in be relocated in an inferior direction[59]. This growth produces a posterior and inferior displacement of the condyle which has a subsequent counter-clockwise rotational effect on the ramus and mandible, allowing the anterior dentition to be anteriorly positioned relative to the maxillary dentition[59].

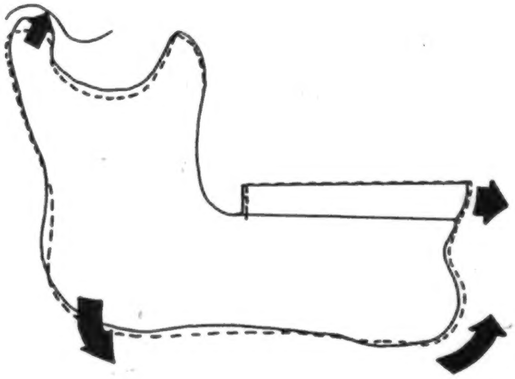

Figure 1.8: Counter-clockwise Rotation of the Mandible

As the condyle enlarges by appositional growth, its proportions are maintained by remodeling on its inferior surfaces so that this region is converted into the new neck region of the condyle. The previously inferior portion of the neck of the condyle is similarly remodeled and contributes to the vertical enlargement of the ramus along its posterior border. This type of remodeling ensures that the condylar dimensions are matched with the increasing dimensions of the temporal articulation and ensures a contribution to the vertical and posterior displacement of the ramus[59].

Intramembranous periosteal bone deposition occurs on the non-articular postero-lateral surface of the condyle. Compensatory endosteal resorption occurs on the internal surface of the cortical plate which relocates this region postero-laterally. On the antero-medial surface of the condyle periosteal resorption occurs with endosteal deposition to relocate this region of the condyle in a transverse direction. This compensatory apposition and resorption ensure that transverse displacement of the condyle matches the expansion of the middle cranial base[23].

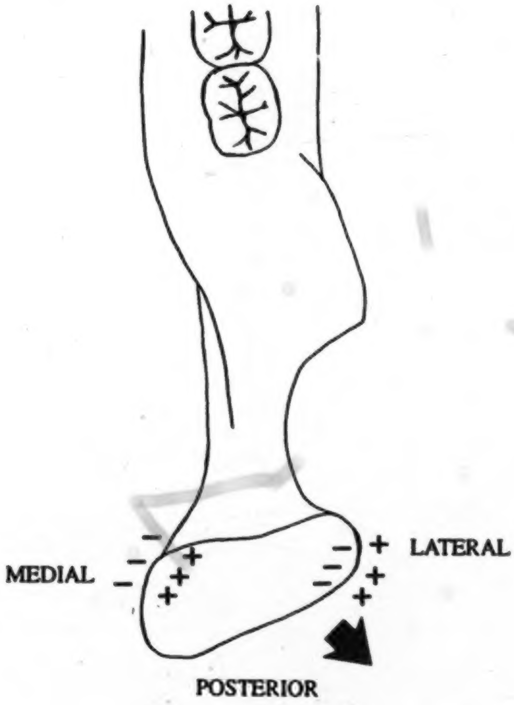

Figure 1.9: Transverse Displacement of the Condyle by Apposition and Resorption

#### 1.3.4.3 Dental Alveolus

The dentoalveolus is an adaptive osseous region that houses the dentition in both the maxillary and mandibular dental arches. The teeth are supported within the alveolar bone by a regular arrangement of collagen fibers attached to the cementum of teeth and surrounding alveolar bone. These fibers constitute the periodontal ligament. The periodontal ligament fibers, its interstitial matrix and cellular components comprise the periodontal membrane. The periodontal membrane is comparable to both a suture and periosteal membrane since bone formation and remodeling occurs here[59].

The fibers of the periodontal ligament are attached superiorly to the dense bony lamina dura of alveolar bone, run inferiorly and insert into the cementum of the tooth. This arrangement of the collagen fibers allows each tooth to be suspended in a connective tissue sling within the dentoalveolus. This sling system converts compressive forces of mastication into tension on the alveolar bone[59]. Tensional pull on bone results in bone deposition due to the tensional effect on the periosteum of bone that stimulates bone deposition by osteoblasts. In contrast, compression of the periodontal membrane or periosteum stimulates osteoclastic cellular activity with a resorptive effect[59,68]. By converting compressive forces into tensional forces the periodontal membrane adequately supports the dentition and also provides a system for tooth eruption.

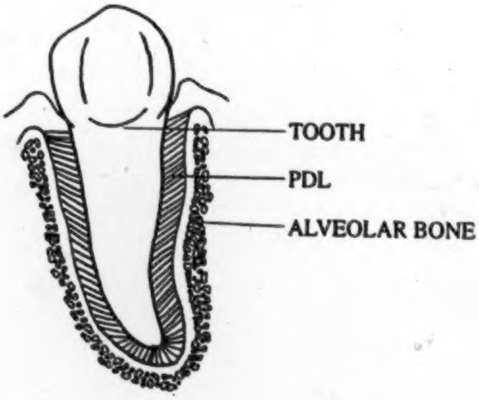

Figure1.10: Periodontal Ligament and Dental Attachment
(PDL: periodontal ligament)

Each periodontal membrane unit is well vascularized and innervated to supply proprioceptive input to the masticatory system. In addition to its function as a proprioceptor, the periodontal membrane acts as a shock absorber and load dissipating structure. The role of the periodontal membrane in eruption of the forming tooth seems evident but the mechanism has not been fully established. The process which determines continued eruption of a tooth which is not in occlusion is still speculative. A number of mechanisms for tooth eruption by the periodontal membrane have been suggested: contractile nature of periodontal ligament fibers, increased blood pressure within the periodontal membrane, root formation with subsequent eruption and continual changes in cross-linkages of collagen fibers in periodontal ligament[68].

Vertical and anterior growth of the mandible occurs as a consequence of ramal and condylar growth, remodeling and displacement. This produces an increased posterior vertical dimension between the maxilla and mandible. Anteriorly, the dentoalveolus responds by increasing the vertical dimensions through a process termed alveolar drift[59]. For alveolar drift to take place, simultaneous vertical movement of the dentition and alveolus occurs[59]. Vertical and anterior tooth eruption is closely followed by vertical development of the alveolar processes of the mandible and maxilla (Figure 1.11). As a consequence the dentition does not actually erupt through the alveolus but the alveolus moves with the teeth. Dentoalveolar drift therefore contributes to the development of anterior vertical facial height[59].

In addition to the vertical displacement of the mandible produced by ramal and condylar relocation and dentoalveolar development, the posterior ramal drift provides an increase in the sagittal length of the mandibular corpus. This increased sagittal dimension of the corpus is utilized for posterior tooth eruption and dentoalveolar vertical development distal to the fully formed primary dentition.

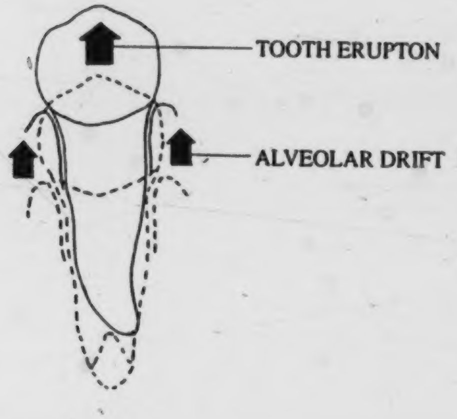

Figure 1.11: Diagrammatic Representation of Tooth Eruption and Alveolar Drift

### 1.3.4.4 Angular Process

The Angular process is a growth field localized on the lateral surface of the mandibular ramus in the region of masseter muscle fiber insertion in lower vertebrates[59]. Secondary cartilage develops in this region in early postnatal life, in response to muscle tension stimulating the periosteal membrane[67]. This growth field is responsible for development of the angle of the mandible in the region posterior to the confluence of the ramus and mandibular corpus and growth is expressed in a postero-inferior and a lateral direction. In time this region becomes well differentiated from the antegonial notch which marks the confluence of the corpus and ramus.

### 1.3.4.5 Coronoid Process

The coronoid process develops as another region of muscle insertion. The tendon of the temporalis muscle inserts into the antero-superior surface of the anterior margin of the ramus. As for the insertion of the masseter muscle, the periosteal response is also the production of secondary cartilage in early postnatal life which is eventually replaced by intramembranous bone formation. The pull of the muscle on the periosteum stimulates bone formation and the development of the coronoid process which grows in the direction of muscle pull, namely, postero-superiorly and medially[59]. In the mature mandible the height of the coronoid process is approximately equal to that of the condyle, its posterior neighbour.

As the coronoid process enlarges it contributes to the vertical development of the ramus on its antero-superior surface. This contribution, together with that of the condylar process, enhances the vertical development of the ramus.

### 1.3.4.6 Mandibular Corpus

The contribution of the ramus to the sagittal development of the corpus has been outlined in section 1.3.4.1. Similarly the vertical development of the corpus has been explained as it relates to vertical dentoalveolar development. In addition to these growth processes that shape the mandibular corpus, apposition and resorption of bone on various surfaces alters the shape and size of the corpus. Osseous remodeling ensures that the corpus enlarges in transverse dimensions and makes space for the complex functioning tongue enclosed medial to it[59].

In summary, the condyle contributes to the anterior and inferior displacement of the mandible as a whole. It does not act as the pace-setting master for displacement of the mandible as expected from a growth centre which exhibits tissue separating potential. Instead, the condyle is adaptive in nature responding to functional and local environmental stimuli. Continuous remodeling of bone ensures that the condylar contribution to facial development is smoothed into the development of the next adaptive region, the ramus. The ramus in turn remodels under functional stimuli and contributes to overall mandibular shape and size that ensures harmonious craniofacial development and function.

As a result of continuous remodeling and osseous displacement the exact contribution of the condyle to mandibular growth in a normal individual cannot accurately be determined by studying the end product of the growth process, namely the mandible. Only by contrasting the size and shape of the mandibular components in normal and abnormally developing individuals can disturbances in the contributions of growth fields be estimated. Even this will be inaccurate due to the compensatory nature of the various osseous growth fields involved in maintaining the functional relationships of the mandible to the craniofacial skeleton.

### 1.3.5 Control Mechanisms of Condylar Development

Numerous mechanisms have been suggested to control condylar development. The traditional concept of mandibular growth was that the condyle was the principal mandibular growth centre and that under the influence of intrinsic genetic factors, condylar growth displaces the mandible downwards and forwards, resulting in the eventual antero-posterior relationship between the mandible and the maxilla[69,70].

According to the Functional Matrix Theory, which is based on the functional cranial components of van der Klaauw[71] and Moss[66], mandibular growth occurs as a secondary or adaptive response of the various mandibular skeletal units to the functional behaviour of the oral cavity and related orofacial musculature (functional matrices). According to Moss' concept, the condylar growth is regulated by extrinsic factors and is merely a skeletal unit forming the mandible[66].

Some of these mechanisms can largely be ignored in light of evidence acquired through animal experiments to determine the proliferative capacity of condylar tissues[13,72]. A number of suggested mechanisms may however be applicable and have been included in a composite model by Van Limborgh[73]. This model has been further modified with the addition of new information regarding the presence of growth factors at the cellular level.

In general, regions of the craniofacial complex grow in harmony, despite some regions responding relatively late to growth changes already experienced by other regions. Changes induced in the anterior and middle cranial fossa by the expanding brain are expressed as cranial base flexure and antero-inferior displacement of the cranial base. The maxilla is affected by this displacement but also responds to other craniofacial mechanisms directing growth. The maxilla is therefore displaced in an antero-inferior as well as transverse direction. The mandible articulates with the lateral regions of the middle cranial fossa and is similarly displaced by brain expansion. In addition the mandible responds to the displaced maxilla through growth remodeling in the various growth fields as discussed in sections 1.3.4.1 to 1.3.4.6.

Petrovic and co-workers[16,74,75] have proposed a model to explain the mechanisms involved in transforming distant craniofacial changes into local growth signals. The origin of the distant signal is the positional change of the maxilla. This signal is transferred to the condyle and temporomandibular joint through a complex interplay of neural input, muscle adaptation, connective tissue responses, blood supply, synovial fluid changes and biochemical growth factor activation or suppression.

### 1.3.5.1 Petrovic's Servosystem Model

The new position of the maxilla is matched by the forward positioning of the mandible and is initially accomplished though contraction of the lateral pterygoid muscles, medial pterygoid and the anterior fibers of the masseter. The proprioceptive stimulus to contraction of these muscular elements is provided by the periodontal membranes of the occluding dentition. In Petrovic's model, the teeth are considered to be the site of operational confrontation and termed "peripheral comparators." Periodontal responses to directional pressure induce neural input to the muscles of mastication to stimulate contraction that facilitates forward positioning of the mandible.

Contraction of the lateral pterygoid muscle sets up a secondary response in the retrodiscal tissues. These tissues show an increase in the blood flow with sustained postural contraction of the lateral pterygoid muscles[75]. Since the retrodiscal tissues are covered by villous synovial membranes which produce synovial fluid, the composition of synovial fluid and the intra-articular pressure are altered as a consequence of muscle contraction. Intra-articular pressure has been shown to increase in response to condylar protrusion[76] and in combination with altered quantity or quality of synovial fluid the pressure may initiate secretion of growth factors that modulate cartilage cell turnover in the temporomandibular joint.

The articular cartilage of the temporomandibular joint is avascular and alymphatic and is therefore insulated from circulating cell signalling molecules to which vascularized tissues are exposed. Therefore the articular cartilage receives such messages via the synovial fluid. These messengers are regulatory cytokines and polypeptide growth factors which are either catabolic, induced by proinflammatory stimuli or anabolic, associated with the production of extracellular matrix and cell replication.

Anabolic responses are primarily stimulated by the release of growth factors such as insulin like growth factor I (IGF I), basic fibroblast growth factor (bFGF), and transforming growth factor beta (TGFβ). Levels of these growth factors are closely modulated and respond to increased levels of catabolic cytokines and metalloproteinases (collagenases, gelatinases and stromelysins) by secreted tissue inhibitors of metalloproteinases (TIMP)[77,78]. The functions of the various growth factors on chondrocyte homeostasis are summarized below[79]:

### 1.3.5.2 Insulin like growth factor I (IGF I)

This factor stimulates both mitotic activity and differentiation of articular chondrocytes. Cells appear to be more sensitive to the matrix synthesizing effects of IGF I than to the mitotic activity of this factor, enhancing the production of collagen and glycosaminoglycans in the presence of IGF I. In addition, IGF I has been shown to augment the stimulatory effects of growth hormone on sulphate incorporation in articular cartilage, thus increasing the matrix component of cartilage[79].

#### 1.3.5.3 Transforming growth factor Beta (TGFβ)

TGFβ stimulates and inhibits proteoglycan synthesis by articular chondrocytes. It has also been shown to stimulate and inhibit proliferation of articular chondrocytes in culture[79].

#### 1.3.5.4 Basic fibroblast growth factor (bFGF)

Basic fibroblast growth factor seems to be capable of regulating both the anabolic and catabolic activity of articular chondrocyte and chondroprogenitor cells[80], but has little effect on matrix synthesis and sulphate incorporation into matrix proteins.

In addition to the effect of the lateral pterygoid muscle on cartilage cell proliferation and matrix synthesis, it has been shown that certain functional compressive forces promote the biosynthetic activity of collagenous matrix and proteoglycans as well as cellular proliferation. These relationships have been demonstrated *in vitro* and *in vivo* studies[13,14,81].

Cartilage production and cellular proliferation is therefore modulated by both positive and negative feedback mechanisms which facilitate condylar cartilage growth essential for fine growth adjustment and insuring an efficient occlusion. The condylar cartilage is easily modifiable and subject to local and regional control mechanisms to ensure coordinated growth of the stomatognathic system. The effect of muscle contraction on development of the ramus and contribution to functional homeostasis should be strongly considered.

### 1.3.6 Summary

It can be concluded that the condylar cartilage in the growing adolescent is responsive to growth stimuli from a host of local and systemic influences. Condylar growth is modulated to keep pace with facial growth and is adaptive to mandibular development. As growth is completed, the role of the condylar cartilage shifts to maintenance of the integrity of the articular tissues. Therefore the condylar cartilage always has an adaptive role, initially in growth and development and in later life, in tissue maintenance. This adaptive role is extremely important in the maintenance of facial balance throughout life. Reduced adaptive capacity of condylar cartilage during growth and development may lead to ramal and mandibular under-development relative to the maxilla. Reduced adaptive capacity in adult life results in tissue breakdown and osseous changes consistent with degenerative processes and osteoarthrosis which may result in bone loss and facial changes. The integrity of the condylar cartilage, whether during growth or articular function, is therefore of considerable importance.

## 1.4 Factors Influencing Normal Condyle Development

In some instances mandibular development does not keep pace with the development of the nasomaxillary complex or associated craniofacial structures. In these situations there is a loss of functional equilibrium which maintains the mandibular dentition in occlusion with that of the maxilla. Loss of equilibrium may be due to over- or under-development of any of the regions contributing to facial growth. For purposes of this review, only factors that may produce either over- or under-development of the mandible will be considered. Development of the mandible may be affected by one or a combination of the following:

- Inherited congenital/ developmental abnormalities,
- Hormonal imbalances,
- Arthritides and/ or,
- Local environmental factors

### 1.4.1 Inherited Congenital/ Developmental Abnormalities

These are abnormalities which develop in-utero or are expressed immediately after birth with growth and development. Congenital abnormalities can involve specific regions of the body or may affect the development of the entire individual. Many abnormalities of this type are non-lethal, but lethal abnormalities are identified. Selected inherited congenital abnormalites that affect mandibular development will be highlighted. These abnormalities produce severe facial alterations as they are expressed from a very early age.

#### 1.4.1.1 Hemifacial Microsomia

Hemifacial Microsomia is the second most common craniofacial deformity after cleft lip and palate, estimated to occur in about 1:5,000 children born[82]. Although termed a congenital abnormality of the first and second branchial arches, the exact etiology is not fully understood. This disorder is expressed as an asymmetric under-development of the temporomandibular joint and ramus of the mandible as far as the antegonial notch. Other structures of the cranioskeleton and craniomandibular muscles are also involved. The disorder manifests as a progressive facial asymmetry which may affect the facial skeleton either unilaterally or bilaterally[83]. Bilateral involvement may occur as frequently as in 20 - 30% of cases. The total deformity is not restricted to the skeleton. The ear may be involved with the development of preauricular skin tags, soft tissue and muscle deficiency may be evident and facial nerve palsy may also be a feature of the disorder[84].

The mandibular anomaly is classified into three types depending on the skeletal anatomy of the ramus and temporomandibular joint[84,85]: A Type I deformity consists of a mature mandible and TMJ, but all TMJ structures are hypoplastic and small. A Type II deformity is characterized by a small, abnormally shaped ramus and an under-developed displaced TMJ. In a Type III deformity both the ramus and the glenoid fossa are absent.

The unilateral sagittal mandibular growth impairment leads to a mandibular skeletal midline deviation to the affected side. The occlusal plane is also affected with a superior tilt of the occlusal plane on the ipsilateral side. Failure of transverse remodeling of the ramus on the affected side results in a narrow ramus and a medially displaced ramus relative to the contralateral side. Maxillary growth is also affected on the side of the mandibular deformity. Downward growth of the maxilla is restricted by the shortened mandible. This restricts the vertical maxillary growth and the vertical distance between the orbital floor and the alveolus is decreased[84].

#### 1.4.1.2 Turner's Syndrome

This syndrome is a relatively common disorder that occurs in 1:2,500 female births and is caused by complete or partial absence of one of the X chromosomes[86]. Growth related anomalies are one of the most significant effects of X chromosome deficiency. The individuals usually present with short stature, cranial growth reduction, decreased mesio-distal dimensions of permanent teeth and early eruption of permanent teeth. A prolonged growth period is observed, caused by a slowing down of the epiphyseal cartilage fusion.

Facial features, evident in individuals affected by this chromosomal abnormality are characterized by a downward and backward rotation of the mandible, a reduced posterior facial height, flattening of the cranial base flexure and bimaxillary retrognathism[87,88].

#### 1.4.1.3 Treacher Collins Syndrome

This disorder usually presents as a bilateral facial deformity characterized by mandibular hypoplasia, deficient malar processes, low-set deformed ears, and an antimongoloid slant to the palpebral fissures. The temporomandibular joints are generally considered to be normal although the condyles are small. The mandible usually has a shortened ramus, shortened corpus, and distinct antegonial notching[89].

#### 1.4.1.4 Hallerman-Streiff Syndrome

Facial deformities in this syndrome resemble Treacher Collins syndrome but in addition, congenital cataracts, and proportional dwarfism are found. The face is small in comparison to the skull, the mandible is narrow and the nose is beaked giving a bird-like facial appearance. In these individuals the temporomandibular joints are located more anteriorly, are hypoplastic and the condyles are small or absent. Despite the anterior position of the joints, the mandible is severely under-developed resulting in a Class II malocclusion with anterior open bite[89].

### 1.4.1.5 Inherited Connective Tissue Diseases

These heterogeneous disorders are inherited as genetic defects causing an error in collagen synthesis or processing. Nine separate and distinct forms are currently recognized and are termed Ehler-Danlos syndromes. These disorders may be innocuous or lethal and present in 1:150,000 births[90].

The skin of these individuals is stretchable, readily bruised and slow to heal. Joints of individuals with Ehler-Danlos syndrome are hypermobile with frequent subluxation and dislocation. Intracapsular hemorrhage and joint effusions are common side-effects of joint hypermobility. Ocular manifestations of the disorder are also evident and present as scleral and corneal fragility with retinal detachment[91].

Several dental and oral manifestations of the disorder are also evident. The teeth may be crenated, smaller than normal or may not develop at all. Dentine structure is affected due to abnormal collagen structure. The pulp may be obliterated with the development of pulp stones and the roots may be dilacerated. The periodontal collagen fibers exhibit cross-linkage defects which may predispose these individuals to earlier and severe periodontal breakdown and development of periodontal defects[91].

Laxity of joint ligaments and frequent subluxation of the joints, especially the temporomandibular joints, may result in hemarthrosis and osteoarthrosis. Abnormal collagen formation predisposes the joint to development of disc displacement which interferes with normal condylar range of movement and translation. The development of osteoarthritic changes within the TMJ produces occlusal instability and posterior rotation of the mandible around the fulcrum of the most distal molar supports. Ultimately, facial changes are evident with decreased posterior facial height and an increased anterior facial height with the development of an anterior skeletal open-bite pattern.

### 1.4.1.6 Inherited Receptor Defects

Fibroblast growth factors (FGFs) and fibroblast growth factor receptors (FGFRs) regulate a multitude of cellular processes, such as cell growth, differentiation, migration, and survival[92]. Mutations in the human fibroblast growth factor receptor 2 (FGFR2) gene result in several different genetically defined syndromes; Crouzon, Pfeiffer, Apert, and Jackson-Weiss[92,93]. All these syndromes are dominantly inherited and involve craniosynostosis, or premature fusion of the cranial sutures. There is variable involvement of the digits, from normal fingers and toes in Crouzons syndrome to severe syndactyly of hands and feet in Apert syndrome[92].

In the normal course of growth, the bones of the neonatal skull are discrete, the limits of adjacent bones being defined by cartilagenous borders that form the cranial sutures. This arrangement of cranial vault bones allows for overlap and compression of the bones in the birth canal as well as enabling appositional growth to occur with maturation of the underlying brain. As the brain matures, a gradual and seemingly coordinated process of suture closure occurs, beginning within weeks of birth, when the posterior fontanelle closes, and ending in the third decade of life when closure of the facial sutures completes the process[92].

Craniosynostosis implies the early fusion of cranial sutures with the development of increased intracranial pressure which requires surgery for correction. Surgical correction increases the space for brain development and improves facial esthetics. Depending on the syndrome diagnosed, the degree of facial involvement varies from less severe to severe involvement with alteration in facial morphology[94].

#### 1.4.1.7 Muscular Dystrophy

The effects of progressive muscular dystrophy on the development of the facial structure have been documented by Kreiborg *et al*[95]. Muscle function has been evaluated by making use of electromyographic recordings of masticatory muscles and muscles of facial expression. The recordings made from the muscles of mastication showed minimal recruitment of the temporalis and masseter muscles during chewing, and minimal activity of the masseters during swallowing. The muscles of facial expression were also flaccid and no lip seal was evident. In addition the motor control of the tongue was deficient with the tongue abnormally positioned and atrophic[95].

Muscular dystrophy and progressive muscular weakness results in changes in the facial skeletal structures. The mandible becomes more retrognathic and posteriorly rotated. The maxilla is similarly affected with posterior rotation[96]. It is believed that the effect of muscle function and the generation of compressional and tensional stressors on the mandible stimulate condylar and periosteal bone development. The lack of compressional stress applied to the condylar cartilage decreases cartilage production and hence a decrease in the contribution to posterior facial height. Reduced periosteal tension on the periosteum of bone generated by muscle contractions also results in reduced bone deposition and remodeling. Maxillary vertical over-development can be attributed to an imbalance of forces on the maxillary dentition which allows for excessive vertical drift of the maxillary dentition and vertical elongation of the face.

The effects of lethal muscular dysgenesis mutation on cartilage and bone development in neonate mice was studied by Herring and Lakars[97]. The authors noted mandibular retrognathia relative to normal age-matched mice. The retrognathia was due to a more dorsally placed mandible rather than an arcial length alteration of the mandible in the mutants. Angular and condylar cartilage did not exhibit any difference in length along the long axis of the cartilage but were reduced in width in the mutants. It was concluded that forces generated by muscle function (or lack thereof) were more important in promoting growth in cartilage width than in length, and that chondrogenesis was more affected than osteogenesis in the mutant fetuses. Reduced compressive and tensile reaction forces on the condylar and argular cartilages as a result of muscular dysgenesis were used to explain the alterations in the cartilage dimensions[97].

### 1.4.2 Hormonal Imbalance

Control of postnatal craniofacial skeletal growth involves a complex interaction of genes, hormones, nutrients and local environmental factors. The craniofacial skeleton is made up of regions which are derived from endochondral as well as intramembranous bone formation. Areas formed through the development of secondary cartilage differ from areas of endochondral bone formation, but contribute to the development of the face. Each of the component areas contributing to facial development have different rates of maturity and growth potential at any particular time, and hence will respond uniquely to hormonal influences.

In acromegaly, for example, excess growth hormone production after puberty results in large mandibles and coarse facial features. These are the structures which have the greatest potential for growth. Linear somatic growth is relatively unaffected by increased levels of growth hormone after growth has been completed. During pubertal growth, growth hormone influences the rapid proliferation of cartilage with new bone formation at epiphyseal growth plates, but is also responsible for the osseous fusion which marks the end of the growth period. When fusion of the diaphysis and epiphysis occurs no further growth takes place at this once active growth centre[98].

Even though the effect of growth hormone on various craniofacial bony components is quite variable, an association between craniofacial and somatic development has been shown[99,100]. Individuals with growth hormone deficiency display significant maturational delays and reduced somatic growth. Dental development of children with growth hormone deficiency is less affected than their somatic growth[101,102], while development of craniofacial structures appears to be affected resulting in immature facial appearance. Growth hormone deficiency in children is reported to result in relatively smaller posterior cranial bases versus anterior cranial base length[101]. The maxilla is similarly reduced in sagittal dimensions and the mandibular length is reduced, primarily as a result of a smaller ramal height. This results in decreased posterior facial height dimensions and increased steepness of the mandibular plane and increased facial convexity[102].

Thyroid hormone is essential for normal growth and skeletal maturation. In thyroid deficient children, bone growth is slowed, epiphyseal closure is delayed and secretion of growth hormone may also be depressed[103]. While some of the effects of thyroid hormone on cartilage and bone may be through pathways common with and dependent upon growth hormone, there appears to be a small growth hormone independent effect. Unlike growth hormone, which has little effect on fetal growth, thyroid hormone does play an important part in regulating fetal growth[104]. In experimental studies on rats, thyroid hormone treatment in the absence of growth hormone was capable of stimulating mandibular condylar cartilage growth[105]. It seems that growth hormone and thyroid hormone have an additive effect on cartilage growth, even though each hormone is effective on a different cell population in the proliferating cartilage. The exact effect of thyroid hormone levels on condylar cartilage is still under investigation.

The effect of sex hormones, in particular estradiol, on growth plates has been investigated. Direct effects of estradiol on prechondrocytes and proliferating chondrocytes has not been shown, and may require growth hormone secretion. Osteoblast-like cells and cells in the hypertrophic and maturational zone of cartilage respond to estradiol by undergoing matrix synthesis, mineralization and maturation. The net effect of prolonged or excessive sex steroid exposure seems to be accelerated maturation and a decreased ultimate somatic height[106].

Insulin and glucocorticoids have significant modulatory influences on the principal growth stimulants and effect growth plates peripherally rather than centrally. These hormones seem to facilitate growth, showing optimal growth during health and adequate nutrition. Stress, nutritional deficiency and illness impose restraints on the growth rate. An imbalance in the secretion of hormones which regulate normal growth and development has an effect on the growing individual as well as the adult. Altered hormonal levels produce an increase or a decrease in the normal tissue response to soft tissue or bone production.

### 1.4.3 Arthritides

#### 1.4.3.1 Juvenile Rheumatoid Arthritis

Juvenile rheumatoid arthritis is a group of disorders with chronic synovitis persistent for at least 6 weeks in one or more joints as a common denominator, with an onset before the age of 16 years[107]. The disease is more common in females and may present as one of three subtypes: systemic, polyarticular, and pauciarticular. Although the TMJ can be involved in any of these subtypes, it is most often affected by the polyarticular form. This inflammatory synovitis has been implicated in altered craniofacial morphology[108-110]. The term "bird faces" was coined to describe individuals exhibiting a convex facial profile and a severely retrognathic mandible[109,111].

Adolescent individuals rarely complain of pain involving the TMJs since pain experienced in other larger peripheral joints (wrists, elbows, ankles) may overshadow the pain experienced in these smaller joints. Pain and limitation in mouth opening does however occur with involvement of the TMJ. The inflammatory pannus initially involve only the connective tissue structures of the joint such as the capsule and attachments of the articular disc. Bony erosions may however occur and are associated with an articular disc which is either reduced or displaced[111,113].

The facial features accompanying involvement of the TMJs are similar to those described for individuals with condylar hypoplasia. The ramus is reduced in vertical height, the condyle is small and malformed and the mandible is rotated posteriorly, increasing the steepness of the mandibular plane[109,110,114,115]. Adaptive dentoalveolar changes accompany the skeletal changes with increased vertical drift of the anterior dentition and reduced eruption of the posterior dentition. Despite these adaptive dentoalveolar changes an open bite may develop in cases of severe joint involvement[115]. Muscle function may be impaired due to limited mouth opening or due to the pain response. Over time these individuals may exhibit muscle atrophy and weakness[116]. Decreased muscle activity may have an effect on development of the condyle and ramus and contribute to the abnormal craniofacial pattern[110]. The severity of this deformity is related to the age of onset of the disease and its duration[110].

### 1.4.3.2 Osteoarthrosis

Dibbets *et al*[3,4,5] carried out pioneering studies on radiographic assessment of the condyle to determine if condylar morphology could be used to predict mandibular growth direction and magnitude. Altered condylar morphology was interpreted to be consistent with osteoarthrosis affecting the TMJ[117]. These studies demonstrated relationships between alteration in facial morphology and altered condylar morphology in an adolescent sample using regression models[3,4,5]. None of the individuals included in the study were previously diagnosed as having juvenile rheumatoid arthritis[3,4,5].

The results of these studies showed that cephalometrically determined alterations in mandibular morphology could be associated with alteration in condylar morphology[3,4,5]. The ramus was shorter, articulare was more superiorly positioned, the corpus was shorter, the mandibular plane was steeper and the posterior facial height was reduced when compared to children with normal condylar morphology[3,4,5].

Furthermore, Dibbets *et al*[3,4,5] studied associations between subjective and objective clinical signs and symptoms and craniofacial morphology. Subjectively defined clinical signs and symptoms and objective clinical signs and symptoms could not be associated with similar facial feature divergence as noted in the sample of children with altered condylar morphology. Instead, these authors only showed an alteration in mandibular position relative to the posterior cranial base in adolescents reporting subjective symptoms of TMJ dysfunction[3,4,5].

In the adult population symptoms of joint pain, limited mouth opening, joint noises and tenderness to palpation may be interpreted as TMJ dysfunction. Some authors have suggested that dysfunction proceeds to degenerative joint changes and osteoarthrosis with accompanying occlusal and facial changes[118]. This sequence of events is opposite to that claimed by Dibbets *et al*[117] who conducted research on adolescents with radiographic evidence of altered condylar morphology. These authors conclude that mandibular growth in children with altered condylar morphology developed an adaptive growth pattern. That is to say, the condyle continues to contribute to the development of the mandible, but the direction of the growth increments are altered. The extent of the growth is reduced such that the condylar contribution no longer keeps pace with remodeling that occurs on the inferior surface of the ramus, and therefore a reduced ramal height is evidenced[3,4,5].

Longitudinal evaluation of the same individuals over a number of years to investigate the effect of orthodontic treatment, extraction and growth was conducted[119-121]. It was concluded that orthodontic therapy, whether extraction or non-extraction, fixed orthodontic apliances or removable appliances had little effect on progression of osteoarthrotic condylar morphology[117,120,121]. Similarly, growth did not seem to produce an increase in severity of remodeling of the condyles previously identified as osteoarthitic[119,120].

### 1.4.4 Local Environmental Factors

The cartilage of the mandibular condyle possesses intrinsic genetic growth potential but should not be viewed as a growth centre. Instead, the growth potential of the condyle is realized in the presence of regulatory hormones capable of stimulating cellular proliferation and matrix synthesis which ultimately increases the size of the condyle. Growth of the condyle is further enhanced by optimal function which requires force generation by the muscles of mastication. Areas of compression are established within the TMJ, while areas of tension on periosteal membranes stimulate appositional bone remodeling[67,97]. Deviation in function will disturb the growth equilibrium of the condyle and lead to morphological changes. A number of factors have been identified as local environmental disturbances.

#### 1.4.4.1 Condylar Hypoplasia

Condylar hypoplasia may be an embryonic abnormality or may develop secondary to trauma or infection. The condyles may be affected unilaterally or bilaterally, resulting in facial asymmetry or mandibular retrognathia. The facial deformity increases in severity during growth as the condylar contribution to normal mandibular development is affected. Loss of articulation between the mandible and temporal bone results in inappropriate muscle recruitment and function which further affects the development of the mandible and the facial deformity[122].

Bjork[111] was able to observe the effects of bilateral condylar hypoplasia on facial development in adolescents by making use of vitallium implants as fixed reference markers. These individuals were followed in longitudinal cephalometric studies and were shown to develop severe facial abnormalities characterized by mandibular retrognathia, reduction in posterior facial height, increased divergence of the facial planes toward the anterior region of the face and increased facial convexity. A reduction in the contribution of the condyles to development of the ramus and mandible was demonstrated, although the effect of altered muscle function and patency of the airways could not be analysed.

Dentoalveolar adaptations were also noted. The anterior alveolar region was abnormally high, with increased prognathism and increased incisor inclination. The anterior teeth were also more severely crowded. An increased overjet and a reduced overbite was evident, with the development of an anterior dental open-bite and lip incompetence. A loss of function associated with loss of condylar processes may have contributed significantly to the pattern of facial deformity noted.

It is not possible to determine the exact extent of condylar contribution to facial development, nor is it possible to determine the effect of function and muscle remodeling on bone. A combination of external environmental factors may therefore contribute to the overall facial pattern achieved. This facial pattern is an adaptation to the new dynamic functional equilibrium between tissues. The impact of this study rests, however, in the fact that local environmental factors (trauma, fracture) severely affect the development of normal facial morphology.

### 1.4.4.2 Mouth-breathing

Linder Aronson demonstrated that the patency of the nasal airway is of great importance in the three-dimensional development of the facial region[123-125]. Experimental studies carried out on primates confirmed the effect of nasal obstruction on head posture and muscle function[126]. These studies showed an open mouth breathing pattern, an alteration in head posture and greater recruitment of facial musculature during inspiration than in normal animals. Animal models are however inappropriate for purposes of studying the effects of nasal obstruction since these animals have a separate nasopharynx and oropharynx unlike humans which have a combined naso- and oropharynx and can breath just as freely through the mouth as through the nose.

Nasal obstruction in humans has however been shown to be accompanied by an alteration in the mode of respiration, with individuals switching predominantly to mouth-breathing. Mouth-breathing has been associated with an alteration in craniocervical posture, with a more extended head position[127]. In individuals with chronic nasal obstruction and mouth-breathing, the mandible is positioned inferiorly and the tongue is placed anteriorly to clear the oropharyngeal airway. This habitual postural position allows for the overeruption of the dentition and an increase in the lower anterior facial height. The altered position of the tongue at rest and during function limits its effect on the transverse development of the maxilla. Alterations in recruitment pattern and strength of masticatory muscle function has been suggested by Ingervall *et al.*[128] but remains to confirmed.

These studies suggest that nasal obstruction induce changes in head posture and rest position of the mandible. The altered position of the mandible may provide sufficient changes in growth direction of the condyle and dentoalveolar regions to produce altered craniofacial growth patterns. Correction of nasal obstruction and mode of respiration has shown that a more natural counter-clockwise direction of mandibular growth is resumed once the nasal airway is cleared[129].

Individuals with chronic nasal obstruction are described as having long narrow faces. These individuals exhibited high narrow palates, extended head posture, increased anterior facial height, increased mandibular plane to cranial base and mandibular retrognathia[130-132]. The extent of facial involvement depends on the degree of nasal obstruction, the age of onset and the duration for which the individual is affected. In addition certain individuals may be more prone to developing nasal obstruction due to allergies.

### 1.4.4.3 Infection, Trauma, and Ankylosis

Localized condylar fracture, infection and ankylosis disturbs the physiology, structure and function of the TMJ. In addition, functional musculature surrounding the joint may be involved, further affecting the normal expression of condylar growth. It is generally accepted that the mandibular condyle is not a growth centre, but rather a growth site which is adaptive in nature, responding to physical, environmental, and hormonal influences[13]. Interference in the normal adaptive capacity of the condyle which contributes to development of the ramus and corpus of the mandible has been shown to result in facial asymmetry[133,134]. Moreover, bilateral involvement of the condyles produces varying degrees of retrognathia of the mandible.

#### 1.4.4.4 Diet Modification and Muscle Weakness

Craniofacial growth patterns were studied in animal experiments where there was an alteration in diet. It was postulated that reduced loading of the condyle associated with a softer diet and a concomitant decrease in force generation by the craniomandibular muscles would result in an altered growth pattern[135,136].

The studies did not show significant growth changes in the craniofacial region, however the following results were obtained[135,136]:

- Less force was developed by the masseter muscles during mastication when the animals were fed a softer diet. The frequency of chewing was doubled with a soft diet and electromyographic activity of the masseter muscle was decreased. Histochemical analysis of muscles indicated a change in the constituent muscle fiber types in the masseter muscle. Masseter muscles in animals fed only on a soft diet had an increase in the proportion of fast fatigue, fast twitch fibers in the muscle.
- The condyle showed local alterations in tissue density and constitution. The articular zone of the condyle, as well as the supporting subchondral bone, became less dense. This was thought to occur due to reduced functional loading of the articular surface of the condyle.

A change from a hard to a soft diet produced localized changes within the condyle and the elevator muscles of mastication. These changes were not severe enough to produce significant facial alterations during the period of investigation. Chronic masticatory muscle under-utilization may occur in subjects with orofacial pain or individuals with chronic nasal obstruction. Although the muscle's ability to generate sufficient force is not lost, the intensity and duration of force generation may be insufficient to stimulate condylar cartilage proliferation. Therefore reduced muscle function could be considered a factor which may influence the local environment of the condyle and result in altered direction, magnitude or quality of condylar growth contribution.

### 1.4.5 Summary

The studies cited here highlight the significance of local and general factors in altering the quantity and quality of condylar development and their contributions to maintaining equilibrium in the face. The importance of local environmental factors in modulating condylar development needs to be stressed once again. These localized alterations may produce a decrease or rarely an increase in the relative contribution to the ramus and mandible. The exact contribution of the condyle to facial development cannot be measured due to continual moulding and remodeling of bony components of the mandible and facial region. The overall change in facial morphology can however be determined by making use of cephalometric measurement techniques.

## 1.5 TMJ Disc Displacement

Disc displacement or internal derangement is defined as the abnormal position of the articular disc relative to the head of the condyle and posterior surface of the articular eminence, with the disc usually displaced in an anterior or anterio-medial direction[9,137]. A comprehensive descriptive classification of the direction of disc displacement has recently been formulated describing the disc position after displacement[8]. It should however be appreciated that disc displacement may vary in severity, affecting joints to differing degrees. Furthermore, disc displacement may not affect the whole joint and therefore the extent of involvement depends on the region of the joint exhibiting disc displacement.

The aim of this overview is to introduce the reader to disc displacement by providing a descriptive classification of disc position. The etiology of disc displacement will be reviewed even though consensus regarding this topic has not been gained. Finally the changes observed within the components of the joint will be discussed as they relate to abnormal disc position.

### 1.5.1 Descriptive Classification

In order to differentiate between normal disc position and disc displacement, a point of inception for normal disc position must be defined. By convention, the disc has been regarded to occupy a normal position within the joint when the posterior band of the articular disc is within ± 10 degrees of the 12 o'clock position of the condyle[138]. This starting point has been applied to direct and indirect sagittal imaging of the joint. Functionally, this requires that the intermediate zone of the disc be interposed between the condyle and the posterior surface of the articular eminence[139]. Clinically, the absence of joint sounds is interpreted as normal disc position, while the presence of joint clicking has been perceived to represent disc displacement.

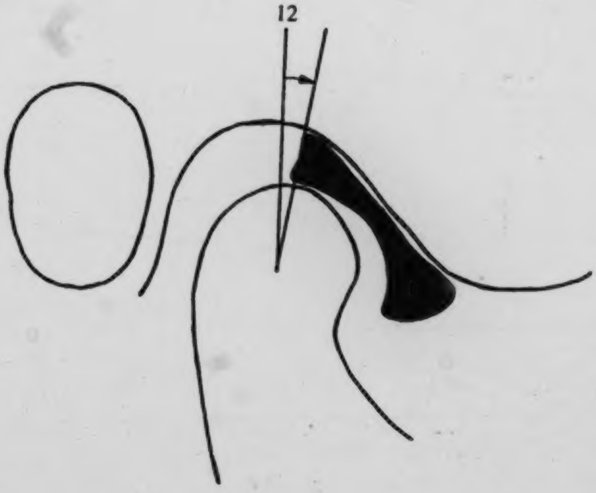

Figure 1.12: Classification of Disc Position according to Drace and Enzmann[138]

Descriptive classifications of disc displacement, based on imaging studies, generally describe the direction in which the disc is displaced but do not describe the region from which the disc originated. This distinction may be more significant when the pathophysiology of disc displacement is considered. For example, investigation of a disc exhibiting antero-medial disc displacement reveals a disc with the majority of its structure located in the antero-medial joint space when the condyle is located within the mandibular fossa. Investigation into the tissue site which has failed to maintain the normal position of the disc reveals that the lateral collateral attachments of the disc are elongated. If the location of tissue damage is considered, this antero-medial disc displacement would be referred to as a lateral disc displacement since it is precisely here that the tissues failed to maintain the integrity of the joint. These are important pointers when considering the classification presented by Tasaki *et al*[8], described below.

Essentially three forms of disc displacement have been recognized using multi-planar Magnetic Resonance Imaging (MRI) for the TMJ[8]:

- Straight Disc Displacement

In the closed mouth position the posterior band of the disc is described as being displaced anterior to the mandibular condyle (Figure 1.13). Straight disc displacement may affect the whole disc or only the medial or lateral region of the disc. Posterior disc displacement has been described [8,140] but is extremely rare if it does occur at all.

- Sideways Disc Displacement

No component of anterior disc displacement is evident, instead the disc assumes a position either lateral or medial to the condyle (Figure 1.13). This form of disc displacement is most evident on coronal MR images of the joint[8].

- Rotational Disc Displacement

The displaced disc exhibits features of a straight disc displacement and a sideways disc displacement[8]. The description of disc position takes into account both the anterior and sideways component of displacement (Figure 1.13). The disc is described as being antero-medially or antero-laterally displaced.

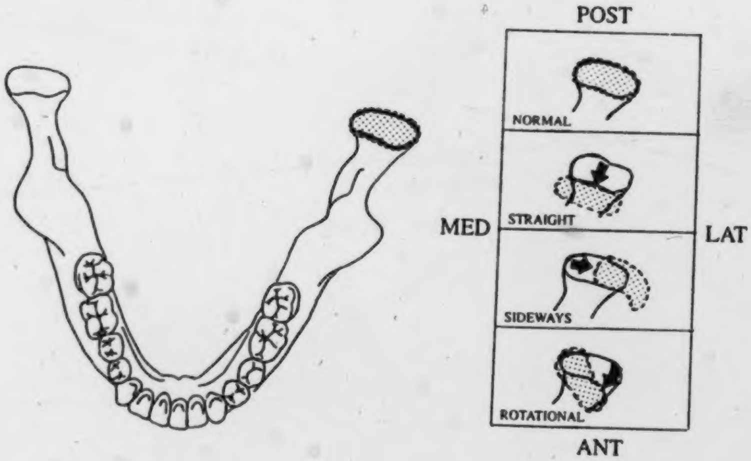

Figure 1.13: Descriptive Classification of Disc Position
(POST: posterior; MED: medial; LAT: lateral; ANT: anterior)

A description of the direction of disc displacement serves to identify the regions of the joint affected, but does not address the severity of the displacement. Subjective evaluation of disc position making use of TMJ imaging has permitted disc displacement to be classified into three broad categories[141-143]. This classification system considers the closed and open mouth disc position:

- Normal Disc Position

In the closed mouth position the posterior band of the disc is situated at the 12 o'clock position relative to the superior surface of the condyle and the intermediate zone of the disc is interposed between the condyle and posterior surface of the articular eminence. As the mouth is fully opened and the condyle translates to the height of the articular eminence, the intermediate zone of the disc remains interposed between the condyle and the posterior slope of the eminence (Figure 1.14).

- Disc Displacement with Reduction

The disc is anteriorly displaced and the posterior band is no longer within 10 degrees of the 12 o'clock position with the teeth in occlusion. According to this classification the disc may be fully displaced or only partially displaced. With mouth opening, the condyle translates down the posterior surface of the articular eminence and in the process re-establishes a normal relationship with the intermediate zone of the articular disc. This is termed disc reduction (Figure 1.14).

- Disc Displacement without Reduction

In the closed mouth position the disc is fully displaced with no portion of the disc interposed between the osseous articular surfaces. On mouth opening, the disc remains anteriorly displaced and does not assume a normal reduced position relative to the osseous articular surfaces (Figure 1.14).

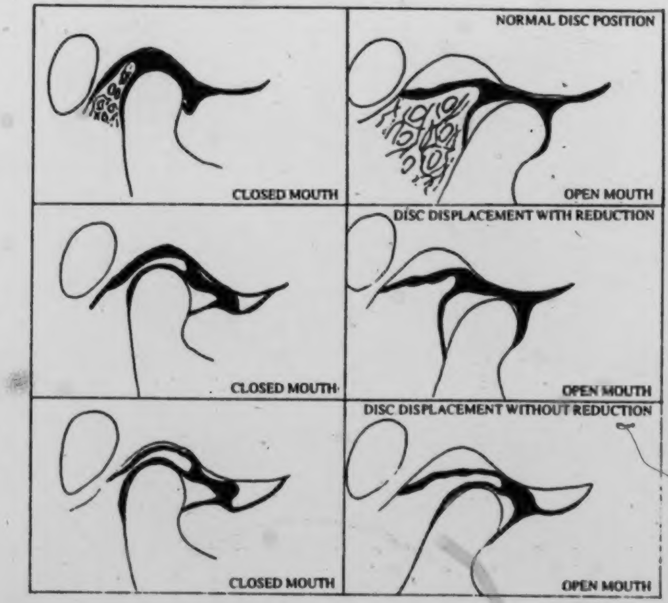
NORMAL DISC POSITION
CLOSED MOUTH
OPEN MOUTH
DISC DISPLACEMENT WITH REDUCTION
CLOSED MOUTH
OPEN MOUTH
DISC DISPLACEMENT WITHOUT REDUCTION
CLOSED MOUTH
OPEN MOUTH

Figure 1.14: Dynamic Description of Disc Position

Clinical evaluations of disc position by means of auscultation, palpation, stethoscopic evaluation, accelerometry or jaw tracing devices are unable to determine the direction of disc displacement, but may be able to detect the presence of a displacement. A clicking sound heard or felt on mouth opening may be interpreted as the movement of the condyle over the posterior band of the displaced disc, as the disc is reduced. As this occurs the intermediate zone of the disc once again re-establishes a normal position relative to the condyle. A similar sound may be experienced on mouth closure, as the condyle once again moves over the posterior band of the disc leaving the disc anteriorly displaced in the closed mouth position[144]. The lack of joint sounds should however not necessarily be interpreted as normal disc position. Joints with a fully displaced disc which do not reduce on mouth opening may be silent, resulting in a false-negative identification of disc displacement. Therefore, other signs and symptoms of disc displacement have to be taken into consideration when only a clinical evaluation is used to determine the position of the articular disc.

The reported prevalence of disc displacement from clinical evaluation varies significantly because of differences in descriptive terminology, data collection, analytical approaches and individual factors selected for study[145-148]. Imaging by arthrography or arthroscopy has not improved the high degree of variation, since these imaging modalities are typically applied only to individuals with severe signs and symptoms[143,149]. Therefore the prevalence of disc displacement in the general population as detected by these techniques is undetermined. With the development of MRI for TMJ, a non-invasive, pain-free imaging modality has emerged which is capable of determining the prevalence of disc displacement. To date, MRI studies have revealed a ±30% prevalence of disc displacement in asymptomatic individuals[7,150,151], and ±86% in individuals complaining of joint symptoms[150]. These figures may seem high, but do not indicate the severity of disc displacement or whether differences in disc displacement severity occur between symptomatic and asymptomatic individuals.

### 1.5.2 Pathogenesis of Disc Displacement

The pathogenesis of disc displacement remains a controversial issue despite factors predisposing, initiating, perpetuating and associated with disc displacement having been identified[144]. A specific cause of disc displacement has been difficult to determine due to numerous factors which may have an influence on disc position. Factors which have been investigated in order to determine their role in disc position are as follows:

- Macrotrauma

Direct trauma to the joint or trauma to the mandible while the teeth are separated may excessively load the articular or non-articular soft tissues resulting in tissue damage, elongation of supporting ligaments or perforation of discal attachments[152,153]. Tissue damage due to excessive forces can lead to fibrillation of discal tissue, inflammation and fibrosis of retrodiscal tissues which impedes the normal function of the joint[154,155]. Abnormal joint function on roughened articular surfaces may further perpetuate tissue damage resulting in elongation of discal ligaments and secondary disc displacement.

- Microtrauma

Parafunctional activity in the form of abnormal oral habits, bruxism or clenching excessively load the articular surfaces. The loads are usually applied while the mandible is in an abnormal, non-functional position. Excessive loading of articular tissue for extended periods of time exhausts the tissues' capacity to maintain and regenerate damaged tissue. Without normal tissue repair occurring, tissue breakdown ensues with articular surface fibrillation, loss of proteoglycans, loss of tissue compressiveness and formation of micro-adhesions[48,156]. Decreased compressibility and loss of normal discal morphology in the posterior band of the disc, together with alterations in discal mobility may lead to elongation of discal ligaments and disc displacement[25].

- Joint Hypermobility

Overextension of the jaw may occur in traumatic episodes, oral intubation[157], third molar extraction procedures, prolonged dental appointments or yawning. The overextension potentially causes elongation of discal ligaments. Patients are at increased risk to this injury if they are sedated and normal joint stabilization by the muscles is reduced[25]. Associations between joint sounds and increased maximal mouth opening have been shown in an adolescent sample, but the significance of joint hypermobility still needs to be investigated[158].

- Occlusal Instability

A lack of orthopedic stability within the masticatory system has been suggested as a contributing factor in the development of internal derangement. Orthopedic instability occurs when the intercuspal position of the teeth is not in harmony with the musculoskeletally stable position of the condyles[159]. Microtrauma to the disc occurs when masticatory forces are applied and the jaw shifts from the musculoskeletally stable position to dental intercuspation. At this stage the condyles are no longer in a stable relationship in the fossae and abnormal joint loading occurs. This may be damaging to joint structures particularly when joint loading is excessive or for extended periods of time.

Other occlusal features that have been investigated for association with internal derangement are:

Posterior occlusal crossbite relationships[160,161], cuspal interferences[162], Angle Class II malocclusions[158,160,163], increased incisal overjet and overbite[160,161,164,165], decreased overbite[160,166] and loss of posterior molar support. A literature review indicates that there are as many studies supporting occlusal factors as contributory to disc displacement[160,167,168] as there are studies refuting the associations[158,162,163,165,169]. Consideration should however be given to the idea that occlusal changes may be the result, rather than the cause of internal derangement.

- Osteoarthrosis

It has been suggested that osteoarthrosis may occur secondary to disc displacement because of the loss of load-distributing ability provided by the disc[1]. Osteoarthrosis may also be a consequence of mechanical overloading of the joint and may occur prior to the onset of disc displacement. Changes in articular surfaces due to excessive loading can induce degenerative changes in the disc. Therefore it has been proposed that disc displacement may be a sign of osteoarthrosis rather than a cause[170].

- Action of the Lateral Pterygoid Muscle

The superior head of the lateral pterygoid muscle has also been implicated in the pathogenesis of disc displacement[171]. Although variable, attachments of the superior head of the lateral pterygoid muscle into the antero-medial portion of the articular disc have been identified[32]. It is suggested that in instances of uncoordinated muscle function or muscle hyperactivity, contraction of the lateral pterygoid muscle predisposes the discal ligaments to elongation and disc displacement.

### 1.5.3 Pathophysiology of Disc Displacement

Disc displacement is associated with varying clinical signs and symptoms as well as varying degrees of tissue change within joint structures. Minor disc displacement affecting only a small region of the disc may pass unnoticed and show little evidence of tissue change. Similarly, disc displacement with reduction may show only minor tissue changes since most of the loading during joint function occurs on the reduced articular disc, preserving the integrity of the retrodiscal tissues and discal attachments. On the other hand, disc displacement without reduction may be associated with severe changes of the articular structures, particularly when joint loading continues to be excessive. Articular and non-articular components of the joint may show changes as a result of disc displacement.

#### 1.5.3.1 The Articular Disc and Posterior Attachment

Displacement of the disc in an anterior or rotational direction with or without reduction implies that during some stages of joint loading the intermediate zone of the disc will not be interposed between the condyle and posterior surface of the articular eminence. Where the disc is only slightly anteriorly displaced, joint loading will occur on the thickened posterior band of the disc. Collagen in this region of the disc has a transverse arrangement and is less capable of supporting functional loads than the intermediate zone of the disc which has a sagittal collagen orientation[26,27]. In addition, the concentration and constitution of proteoglycans in posterior band are different[29]. It has been demonstrated that over time the collagen structure becomes compressed, disturbing its ability to trap proteoglycans and joint fluid resulting in flattening out of the posterior band of the disc[48]. This may promote further joint instability and disc displacement.

The compressibility of discal tissue is reduced with the loss of discal fluid, and loading in this region produces increased tissue damage. Loss of lubrication normally provided by the disc[20,172] together with increased frictional drag from collagen surface fibrillation, disturbs the coordinated movement of the disc relative to the condyle[173]. Increased translational movements that occur in the inferior joint space between the disc and condyle as a consequence of elongated attachments create further elongation of the posterior condylar attachments of the disc resulting in increased disc displacement.

In the closed mouth position with full disc displacement, the condyle rests on the posterior attachments and retrodiscal tissues of the disc. The highly innervated and vascularized retrodiscal tissues are subject to loading and trauma with the release of substance P and prostaglandins which stimulate c-fibre nerve endings producing joint symptoms of pain. At first the tissue damage and compression produce acute cellular infiltrate accompanied by fluid exudate and swelling. The release of cytokines, specifically interleukin 1, induces catabolic responses in chondrocytes which stimulates the expression of proteases, collagenases, and monocyte chemoattractant proteins. Interleukin 1 suppresses procollagen formation and proteoglycan synthesis in chondrocytes and inhibits chondrocyte hypertrophy and the onset of calcification in ossifying cartilage. In summary, interleukin 1 is a potent inhibitor of matrix synthesis and proliferation and induces proteases resulting in cartilage resorption[78]. Fibrocytes within the disc are similarly affected by cytokines with reduced collagen and matrix synthesis[174].

Joint inflammation is often described as a response that occurs in synovial membrane or fluid. Inflammatory cell infiltrates are not prominent in cartilage or articular disc unless there is pannus formation. Cartilage and disc have thus not been regarded as active participants in joint inflammation. However, the production of potent proinflammatory mediators by chondrocytes and fibrocytes is now known to initiate and maintain joint inflammation[78]. Continued functional loading on retrodiscal tissue in the presence of acute inflammation, reduced tissue repair and regeneration, may lead to perforation of the posterior attachments which further interferes with condylar mobility.

Alternatively, the tissue switches to a reparative mode as granulation tissue replaces the acute inflammatory exudate and fibrous scar tissue eventually replaces the retrodiscal tissues. This tissue assumes the function of the displaced disc, the collagen fibers become more regularly arranged and the proteoglycan content of the tissues increases. The symptoms experienced by the patient decrease as the sinusoidal blood vessels and vascular plexus are occluded and nerves degenerate. The retrodiscal tissues remodel into a functional pseudodisc and a new equilibrium is established[175].

Continued joint function and remodeling of the posterior attachments is accompanied by morphological changes in the disc. In the closed mouth position a fully displaced disc is situated anterior to the condyle in the anterior joint recess at the height of the articular eminence[154]. This area is only a potential joint space that extends beyond the height of the eminence. Without elongation of the superior and inferior anterior discal attachments this space is extremely limited by the attachment and function of the lateral pterygoid muscle. In addition, on mouth opening the condyle translates into this space and pushes the disc ahead of it without reduction. As a consequence of the limited space available to contain the disc in its fully extended form, the disc buckles in the region of the intermediate zone. The direction of the bend can be either superior or inferior, depending on the limitations of the functional environment. The collagen fibers in the intermediate zone of the disc are remodeled, with those on the acute surface of the bend assuming a more radial arrangement instead of the original sagittal orientation[154].

The posterior band of the disc shows an increase in thickness possibly related to the continual pressure experienced on its posterior surface during condylar translation. The collagen arrangement in this region of the disc remains altered but may assume a more sagittal orientation. The fluid content is also increased, but this is not necessarily accompanied by an increase in proteoglycan content. Overall the disc shows a loss of morphology and a reduction in antero-posterior dimensions has been suggested[176-180].

### 1.5.3.2 Fibrocartilage and Osseous Articular Surfaces

Minimal disc displacement ensures that during most functional movements of the condyle, the disc is interposed between the functional osseous articular surfaces. The normal articular position of the disc provides the fibrocartilage of the joint with lubrication and nutrition. The disc also functions as a shock-absorber and load-distributor during mastication. Displacement of the disc disrupts the normal function provided by the disc.

In the presence of disc displacement, areas of the condyle not in contact with the articular disc are approximated to the osseous articular surface of the articular eminence with elongated discal attachments interposed. The opposing osseous articular surfaces are incongruous, since the articular disc usually fills the space between the two convex osseous surfaces. During mastication the incongruous surfaces are approximated with point localization of loads. The force per unit area experienced by the fibrocartilage covering the osseous articular structures is increased during mastication, leading to localized tissue fatigue, loss of tissue fluid and reduced compressibility. Proteoglycan content is reduced as a result of the breakdown of surface collagen which occurs due to excessive load applied to the tissues[173].

Initially the damage is localized to the surface articular layer of the fibrocartilage and further damage is prevented by normal tissue regenerative capacity. Continual loading of the joint together with reduced surface lubrication and nutrition eventually affects the regenerative capacity of chondrocytes within the cartilage. Loss of chondrocytes due to decreased maintenance of the tissue results in a reduction in the amount of collagen and interstitial matrix synthesized, with an overall decrease in articular cartilage integrity. At this stage regressive remodeling exceeds the attempts at tissue repair and tissue breakdown and degeneration occurs[173]. The breakdown may be superficially localized to the articular cartilage or extend more deeply to involve the osseous tissues.

The involvement of the osseous tissues is considered to be indirect since the cortical margin of the bone is not initially affected but rather the underlying trabeculae. These fine radially arranged trabeculae may fracture due to excessive point localization of loads and decreased compressibility of the overlying cartilage. The fractured trabeculae stimulate an inflammatory response, activating osteoclasts and osteoblasts. Fractured trabeculae are resorbed leaving an inflammatory microcyst or they may be repaired by callus formation producing regions of subchondral sclerosis and thickening of bone[181].

The severity of surface damage depends on the degree of disc displacement, the presence of posterior discal attachment perforations, loss of lubrication, inflammation, regenerative capacity of tissues, and the duration and intensity of masticatory force application. Damage to the fibrocartilage articular surface is not experienced as joint pain since no nerve endings extend to innervate this tissue. Pain may only be experienced once the nerves in elongated capsular and discal structures are stimulated or when inflammatory products stimulate nerve endings in the osseous medullary spaces.

### 1.5.3.3 Synovial Membrane and Synovial Fluid

A synovial membrane lines the non-articular surfaces of the joint and produces synovial fluid for joint lubrication and nutrition. These membranes line the inner surfaces of the posterior discal attachments which are interposed between the condyle and posterior surface of the articular eminence once the disc is fully displaced. Synovial membrane is delicate and well-supplied by a sub-intimal vascular plexus which is unable withstand joint loads, and for this reason does not occur on articular surfaces.

Loading of synovial tissues, as occurs with disc displacement, results in hyperaemia with the formation of chronic inflammatory exudate and cellular infiltration in the subintimal tissues. Compression of tissues exceeds their adaptive capacity resulting in tissue breakdown and reducing the surface area covered by synovial membrane. This in turn affects the quantity and quality of the synovial fluid produced. Macromolecular protein structures are released into the joint fluid as a result of tissue breakdown or are secreted from inflammatory cells. These large proteins are osmotically active and increase the diffusion of fluids and solutes into the joint space, increasing intra-articular pressure. Normal mouth opening and closing produces an increase in the intra-articular pressure. The pressure may be further elevated, depending on muscle recruitment and occlusal contacts employed during mastication. In the chronically inflammed joint an increase in intra-articular pressure occurs with function which exceeds the capillary perfusion pressure and occludes the synovial capillary bed resulting in hypoxia[182].

Hypoxia during function is damaging to the tissues, but the joint is subject to further damage once function ceases, the intra-articular pressure reduces, and blood re-perfuses the subintimal tissues. A large gradient for oxygen diffusion into joint tissues is established as a result of the oxygen debt produced during mastication. Oxygen delivered to the tissues of the joint during rest is converted to superoxide radicals and hydrogen peroxide by the intimal cells. These oxygen radicals contribute to the persistence of chronic inflammation[183], and oxidative damage to lipids and immunoglobulins IgG[184]. This process is termed hypoxic-reperfusion[183].

### 1.5.4 Summary

In the joint with a chronically displaced disc there is an alteration in the normal functional environment of the joint. The disc is displaced and unable to provide load dissipation, lubrication and nutrition to functional joint surfaces. As function continues, damage occurs to tissues which are usually not loaded or exposed to compressive and shear stresses of mastication. Retrodiscal tissues interposed between the articular surfaces are loaded and tissue breakdown occurs. Fibrocartilage is damaged due to excessive point application of loads between incongruous osseous articular surfaces. Damaged tissue responds with an acute inflammation and fluid exudate which with continued function and tissue breakdown, is converted to a chronic inflammation with fibrosis.

As a result of synovial intimal cell damage, the intimal cells are less capable of preventing large macromolecular proteins from entering the joint space, and in addition show reduced production of hyaluronic acid and proteoglycans. Loss of these synovial fluid constituents lead to reduced efficiency of joint lubrication while the addition of macromolecules to synovial fluid alters the viscosity of the fluid and its lubrication properties. The production of inflammatory exudate and inflammatory products increase the viscosity of synovial fluid and raise the intra-articular pressure, reducing joint perfusion. Reduced perfusion affects the delivery of nutrients and oxygen to articular surfaces and results in a build-up of metabolic waste products within the joint. Continual joint function and hypoxia creates a gradient for oxygen diffusion that results in joint damage by hypoxic-reperfusion.

## 1.6 Assessment of Disc Displacement

As technological application in TMJ investigation advance, finding and keeping a gold standard for assessment of all TMJ patients for all occasions has proven to be narrow-minded and problematic. What is increasingly important, is the ability to select an appropriate assessment modality for a given clinical question. Over time, the assessment of disc position has evolved and become more sophisticated. Numerous attempts have been made at determining the position of the disc in asymptomatic and symptomatic individuals. This led to the development of diagnostic techniques for evaluation of joint status, but the lack of scientific validation for many tests has produced false-positive and false-negative diagnoses. The relative merits and disadvantages of the various techniques for determination of disc status and position will be addressed.

### 1.6.1 Clinical Evaluation

Craniomandibular disorders are characterized by a host of clinical signs and symptoms. Symptoms may be present in the masticatory muscle, the joint or in both structures. In addition the patient may complain of headaches and symptoms of neck pain and stiffness. An evaluation of the presenting signs and symptoms is most often not specific for a single disorder as a wide overlap of presenting features may occur. In these instances special investigations into the quality and quantity of joint and muscle function are important to determine the origin of the disorder.

A clinical evaluation for the determination of disc displacement needs to investigate the signs and symptoms emanating from the joint and surrounding musculature. The joint should be investigated for the presence of joint noises which may indicate the presence of a disc displacement[9,185]. Furthermore the quality of joint movement needs to be evaluated for the presence of deviations on mouth opening, lack of condylar translation and irregular condylar movement. Decreased maximal mouth opening may occur in the presence of altered condylar rotation and translation movements as a result of disc displacement without reduction. Palpation of capsular structures may elicit acute tenderness and be an indication of capsular inflammation.

An evaluation of elevator muscle tenderness and tonicity of the muscles may be an indication of muscle splinting or guarding which occurs in response to joint damage. A reduction in maximal mouth opening due to muscle splinting or spasm is often described as a soft-end feel as compared to a hard-end feel which occurs with a closed lock due to disc displacement without reduction. Muscle symptoms in the absence of joint symptoms may be an indication of muscle overuse as occurs with parafunctional habits[9].

The interpretation of clinical signs and symptoms is complicated by the lack of standardization in obtaining clinical information, the subjective nature of the evaluation and the fact that ambiguous findings may be attributed to the investigation. For example, the detection of a silent joint is generally interpreted as normal disc position. This may not necessarily be the case, since in joints with disc displacement without reduction the condyle may translate normally and no longer move over the posterior band of the disc, producing no joint sounds and leading to a false-negative interpretation of disc position[186]. Therefore joint sounds may not be accurate indicators of disc status unless an accurate history of joint sounds is obtained.

Lack of standardization in the determination of subjective and quantitative clinical measures result in poor reproducibility and reliability of clinical assessment techniques[162]. Improvements in clinical data acquisition have been made possible using visual analog scales for pain scores and standardization of palpation pressures to assess muscle and joint tenderness. Interobserver reliability measures in obtaining clinical information according to set criteria have improved the meaning of clinical evaluations[187]. Despite these improvements, clinical information and joint sounds only identify approximately half of the joints affected by internal derangement as assessed by MRI[188].

Determination of occlusal variables that are clinically assessed, and potentially associated with joint symptoms have lead to contradictory and confusing results. Some studies report associations between Angle malocclusions, crossbites, overbite and overjet measurements and joint symptoms, while other studies show no associations[158,162]. It appears that clinical signs and symptoms are at best indicators of disc displacement but cannot be used with confidence in the diagnosis of joint status or for determining the extent of the disc displacement.

### 1.6.2 Sonography /Doppler /Accelerometry

Sonography is a technique of recording and graphically representing sound. In Doppler ultrasonography, ultrasound echoes are converted to amplified audible waves as the ultrasonic transmissions bounce off moving tissues within the TMJ. Interpretation of these waves has been suggested to determine the presence and location of the click corresponding to disc reduction on mouth opening. Problems are however encountered with the recording of background noise as well as the interpretation of other joint sounds which are present even in "silent joints[189]." The clinical significance and reproducibility of sound emanating from the TMJ are still unclear[190].

Accelerometry is the transduction of vibratory movements of the condyle during movement into spectral frequency distributions for assessment of disc displacement. Observations from a study examining joint sounds in autopsy specimens point out that joint sounds, such as clicking and crepitation, occur only in joints with disc dysfunction and/or arthrotic changes of the articular cartilage[186]. It is however important to note that extensive changes could be present in joints without sounds occurring during any movements. Therefore the interpretation of results from these recording devices is not specific enough to determine the status of the temporomandibular joint disc at this stage.

### 1.6.3 Axiography

One of the signs of disc displacement is impairment of the quality and extent of jaw movement. Techniques have been developed which attempt to quantify jaw movements associated with disc displacement. From simple observation of incisal movement on opening, facebow recordings with pens as recorders were developed (pantography). An irregularity in the path of condylar translation is interpreted to represent the point at which the condyle encounters the posterior band of the displaced disc. Precise three-dimensional tracking of jaw movement making use of magnetic fields and magnets attached to mandibular incisors has also been attempted[191].

The interpretation of these axiographic recordings is uncertain in view of the sparse and unreplicated scientific evidence linking jaw tracking devices to the diagnosis of disc displacement[192]. At present there is insufficient scientific evidence to support the use of jaw-tracking devices in the diagnosis of disc displacement[193].

### 1.6.4 Plain Film Radiography

Plain film radiography of the temporomandibular joint includes transcranial, transpharyngeal, transmaxillary, transorbital, and submental vertex views. These radiographic techniques are used as initial screening modalities for investigation of joint disease[194]. Transcranial radiographs are used to determine the relationship between the condyle and mandibular fossa in the lateral third of the joint in the open and closed mouth positions, and to provide information on the general shape and internal structure of the condyle. They are however difficult to interpret and quantify due to the superimposition of other osseous structures[190].

The use of transmaxillary or transorbital techniques in combination with transcranial radiographs may enhance diagnostic accuracy when assessing degenerative conditions of the condyle[190]. These views obtained perpendicular to the transcranial view aid in identification of irregularities on the surface of the condyle. Transcranial radiographs have been used to evaluate disc position by measuring joint space[195-197], but the general consensus is that transcranial radiographs are unreliable for interpretation of disc position based on the relationship of the condyle to the mandibular fossa[194]. Bean *et al*[198] were unable to show differences in the joint space narrowing in the centric occlusion position between symptomatic and asymptomatic individuals. Similar results were expressed by Katzberg *et al*[199] concerning the diagnosis of disc position through evaluation of condylar position on transcranial projections or tomograms of the TMJ.

Panoramic radiographs can be used as screening images of the TMJ since they are adequate for the detection of fractures and gross degenerative changes of the condyles. As with any of the other plain film imaging techniques, these images have limitations since they are subject to magnification, superimposition, and decreased image resolution. In addition, the formed image of the condyle needs careful interpretation since the orbiting radiation source produces superimposed projections of the medial and lateral poles of the condyle and distortion of osseous structures[200].

In summary, plain film radiographs are able to depict osseous articular detail, but direct imaging of the articular disc is not possible. Attempts at indirect determination of disc position making use of joint space analysis has not proved to be reliable or accurate. These imaging modalities are therefore of limited application in the determination of disc position and status.

### 1.6.5 Tomography

Tomographic images are produced by opposite movements of the x-ray source and the film plate. Images are produced at the intersection of the two orbits of movement while structures in the foreground and background to the intersection are blurred[200]. Multidirectional (hypocycloidal) tomography was developed to enhance the detail and accuracy that could be achieved, by producing sectional views through the joint. Individualized tomography which corrects for both the vertical and horizontal condylar angulation provides images of improved clarity, free of distortion.

Tomography has enabled the joint to be investigated beyond the previously established boundary of the lateral third of the joint. Tomographic slices of the joint can be produced in any region of the joint to study the osseous architecture and spatial relationships between them. Posterior displacement of the condyle relative to the mandibular fossa has been suggested to predict the presence of anterior disc displacement on these images[201,202]. The findings of Brand *et al*[203] show that anterior disc displacement failed to alter the apparent condylar position more frequently than retropositioning of the condyle occurred in the absence of anterior disc displacement. Similar results were concluded from other investigations which set out to determine disc position using tomography[197,199,204].

It should be noted that there is large variation in condylar position in tomographic studies as well as in plain film imaging of both symptomatic and asymptomatic individuals. In addition, the shape of the condyle does not duplicate the often irregular shape of the fossa. The condyle may therefore appear to have different positions in the medial and lateral aspects of the joint which are not determined by the position of the articular disc[205]. Direct imaging of the disc to resolve the position of the articular disc is not possible with the use of this technique. A great deal of information concerning the osseous structures may however be gained by using this imaging modality.

### 1.6.6 Computer Tomography

The strength of these digital images resides in its capability of revealing small bone detail such as erosions or small sequestra within the condylar head. Other applications include the determination of the extent of osseous ankylosis in a joint and three-dimensional reformatted images to determine the extent of tumour involvement[205]. Although more bony detail is revealed with Computed Tomography (CT) than with tomography, tomography is less costly and delivers a smaller absorbed dose of radiation than CT.

The determination of disc position has been reported making use of CT imaging[206-208]. The distortion or obliteration of the normal density of the lateral pterygoid fat pad is interpreted as disc displacement[206]. Direct images of the disc are however poorly defined and difficult to interpret. At present CT cannot play a major role in the evaluation of disc displacement because of the poor reliability in imaging the disc[194,209]. Remodeling of bony surfaces associated with disc displacement are however well depicted. Typical remodeling changes include an increase in the radius of curvature of the mandibular fossa, flattening of the articular eminence and condyle, increase in sclerosis of the antero-superior surface of the condyle and posterior slope of the articular eminence, and interruption of the cortical outline of the condyle[139].

In summary, CT provides exquisite detail for bony abnormalities such as ankylosis, fractures, osseous tumours, and arthrosis. The technique provides some information concerning the soft tissues but is not recommended as the primary imaging modality for diagnosis of disc displacement.

### 1.6.7 Arthrography and Arthoscopy

Arthrography involves injection of radiopaque contrast fluid into the joint spaces to provide an indirect image of the articular disc. This provides information regarding the shape and position of the disc. Furthermore, the flow of contrast medium in the joint space reveals the presence of adhesions, perforations or abnormal accumulations of joint fluid. Dynamic movements of the joint and disc can be recorded by utilizing fluoroscopy and videotaping. Three arthrographic techniques are available to investigate the joint: inferior joint space single contrast, dual space double contrast, and dual space single contrast[205].

Dual space single contrast involves injection of contrast fluid into both joint compartments, while single space contrast involves introduction of contrast fluid into only one joint space. Single space contrast does not provide acceptable images of the disc. Dual space double contrast involves injection of contrast medium into both joint compartments followed by removal of the contrast medium and injection of air. This provides increased contrast with the surrounding soft tissues saturated with contrast medium[205].

Arthrography as an imaging technique is highly sensitive in confirming discal abnormalities such as perforation in the posterior disc attachment, which is most frequently found in long-standing TMJ disorders with osteoarthrotic development[176].

Studies on cadaver material have revealed an accuracy of 97% in the identification of perforations using arthrography[177]. The accuracy of arthrography in determining the position of the articular disc in the sagittal plane has been reported to be between 84 - 93%[177,210,211].

The limitations of this technique are however that the disc is not directly imaged and an indirect image of the disc may not accurately depict the different regions of the disc. This occurs particularly when disc displacement and remodeling has taken place. Other limitations of the technique include[194]:

- puncture of the joint compartment is technically difficult,
- the examination may be painful for the patient,
- the patient is exposed to a considerable radiation dose,
- the introduction of contrast fluid distends soft tissue structures disturbing their position,
- potential infection, allergic reaction, facial nerve palsy, and
- the technique is relatively insensitive for detection of medial or lateral sideways disc displacements.

Arthroscopic surgery was developed as a treatment modality but has provided valuable diagnostic information. Diagnostic arthroscopy enables the operator to view the superior joint space for causes of pain and dysfunction. Fiber-optic arthoscopy has allowed visualization of features associated with the pathophysiology of disc displacement. The presence of hyperemia, edema, and hemorrhage in subsynovial tissues may be interpreted as synovitis. New concepts regarding the percentage surface area of the condyle covered by disc may be determined[212]. The specific location and surface area of the condyle not covered by articular disc may improve our knowledge on the pathophysiology of disc displacement if disc function is considered to be essential in the maintenance of articular cartilage. In addition, adhesions of the disc occurring between the roof of the joint space and the disc or discal attachments may be visualized[213].

Arthroscopy is an exciting new imaging technique which shows great potential for diagnosis and treatment. This imaging technique is however invasive, costly and typically only applied to individuals with expected disc displacement or internal derangement. Its use in the evaluation of disc position as a diagnostic tool is therefore limited to a select population.

### 1.6.8 Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) offers a direct form of soft and hard tissue visualization, providing excellent spatial and contrast resolution of tissues on sagittal and coronal MR images of the TMJ[214,215]. Imaging can be performed in any plane, making it easier to depict and interpret displacement, specifically in the medial or lateral direction. MRI offers the advantage of being non-invasive, pain-free, of minimal risk potential, and free of ionizing radiation exposure[194]. In contrast to indirect imaging with arthrography, MRI produces no soft tissue distortion due to injection of contrast medium into the joint space[216].

Continued advances in the development of imaging sequences, magnetic gradients, surface coils and computer software has allowed for improved spatial and contrast resolution[217]. These improvements have resulted in visualization of the following[176]:

$T_2$ weighted images

- for determination of joint effusion and inflammation,
- condylar bone marrow changes consistent with inflammation and sclerosis,

$T_1$ weighted images

- used for the identification of disc morphology and position,
- signal changes within the disc suggestive of changes in proteoglycan composition,
- identification of limited disc mobility interpreted as disc adhesions, and

- detection of pannus formation in chronic inflammatory joint disease.

With state-of-the-art MR technology, an accuracy of more than 90% for cortical erosions, osteophytes, and flattening of the mandibular condyle was found in a study on fresh cadaver TMJs[218]. Accuracy of assessment of disc position making use of both sagittal and coronal MR images of the TMJ was shown to be approximately 90%[218]. Acceptable interobserver agreement (kappa = 0.88) in the interpretation of MR images of disc position in the TMJ have been reported[194,218]. Recent studies have shown that the diagnostic accuracy of MR images is higher than those obtained previously. This is a result of the continual development and improvements in imaging technology which has improved the signal-to-noise ratio[219].

A limitation of MRI is its inability to depict the presence of perforations in the disc or posterior disc attachments. Other limitations to the use of MRI include:

- motion artifacts can destroy the quality of images produced,
- the TMJ contains several tissues that generate signals of grossly different intensities producing images subject to truncation[220] and susceptibility[221] artifacts.
- fluid flow and chemical shift are further complications at high field strengths,
- patients may develop claustrophobia while in the magnetic chamber, and
- presence of metallic prostheses is a contra-indication to imaging.

The current standard for interpretation of TMJ images relies on subjective evaluation and is dependent on examiner experience and familiarity with TMJ morphology, function and pathophysiology. Subjective evaluation of MRI-determined TMJ disc position makes comprehensive use of all diagnostic images obtained in the scanning protocol. Conventional imaging protocols for the TMJ use coronal and sagittal images which provide information regarding disc position throughout the joint. This information is important for determining the degree and direction of disc displacement.

Unfortunately there is no standardization of terminology, nor is there an adequate indication of the degree of the disorder. An understanding of what constitutes a mild disc displacement to one observer may not be in agreement with that of a second observer. More importantly, clinical management may hinge on the choice of terms used by the observer, and the use of misleading terminology makes it difficult to establish the prevalence and incidence of a disorder in the population. Advanced imaging such as MRI deserves quantification of disc information so that the full potential of this imaging modality may be appreciated.

MR imaging of the temporomandibular joint does however provide adequate visualization of the articular disc and joint structures in both the open and closed mouth position. The technique is non-invasive with no known side effects and can be performed with good acceptance on both symptomatic and asymptomatic individuals making it the technique for identification of disc displacement. This is also the chosen imaging modality for evaluation of disc morphology and position in the study presented here. A more detailed description of the tissue response to magnetic fields and the production of images is discussed in detail in the section to follow.

### 1.6.9 Summary

A single gold standard for the interpretation of a disorder such as TMJ internal derangement is problematic. Techniques which are highly accurate in determining the position of the disc may be invasive or expensive for everyday use. On the other hand, clinical evaluation and plain film screening radiographs cannot accurately determine the position of the disc. The use of MRI to determine articular disc position may enhance our ability to utilize clinical information and plain film radiographs which are more readily available. In the future it is hoped that information from a combination of assessment techniques may be utilized to accurately diagnose TMJ internal derangement.

## 1.7 Magnetic Resonance Imaging of the TMJ

Magnetic resonance imaging makes use of the properties of nuclear magnetic fields placed in the environment of a larger externally applied magnetic field to generate images. In this way, images of living tissue are produced when the nuclear magnetic properties of hydrogen nuclei, which constitute a large proportion of living tissue, are excited to emit a signal. MRI has been applied to the TMJ to produce images of hard and soft tissue structures in addition to tissue fluid. The versatility of MRI permits images to be obtained in virtually any plane in the body producing slice information for investigation. Slice acquisition and formatting options appear to be limitless. The aim of this section is to introduce the reader to MRI and to explain how slice information is acquired, and how MRI is unique in providing tissue characterization for tissue differentiation. Once these concepts are understood, MR images of the TMJ will be interpreted with special reference to imaging of the articular disc.

A unique property of tomography, CT and MRI is to provide slice information of anatomical structures. These slices can be compared to anatomical sections in specific planes in various tissues. Each of these imaging modalities produce slice information by processes particular to the imaging modality. Slice selection and formatting in MRI is termed spatial encoding.

### 1.7.1 Spatial Encoding

Living tissue is essentially composed of 80% water, which in turn has two hydrogen atoms/ water molecule. Hydrogen is of considerable interest since it has the most highly magnetic nucleus of all naturally occurring atoms and because of its abundance in living tissues. It is largely the hydrogen in tissue water and body fat that is imaged by MRI. Each hydrogen nucleus may be considered as a small magnet as it possesses positive electrical charge located a small distance from the nuclear centre. The positive charge spins around the nuclear axis and creates a magnetic field, similar to electrical charge flowing in a conductor and producing a magnetic field. Therefore each hydrogen atom has a magnetic field which may interact with an externally applied magnetic field[222].

Hydrogen nuclei placed within an external magnetic field will align the magnetic moments (magnetic fields) of the nuclei parallel to the external magnetic field. The hydrogen nuclei spin (resonate) at the resonant or Larmor frequency which is proportional to the strength of the externally applied magnetic field. For example, in a 1 Tesla magnet the resonant frequency of hydrogen is 42.6 x $10^6$ cycles per second[222].

The hydrogen nucleus placed within the core magnet is stimulated by radio waves. That is, energy of the correct frequency may be absorbed by the hydrogen nucleus and change its energy state. For radio waves to effectively stimulate hydrogen nuclei they have to be tuned to the resonant frequency of the nuclei in a particular magnetic field strength. The nuclei absorb the energy from radio waves and produce nuclear magnetic resonance. After stimulation by radio waves of the appropriate frequency, the hydrogen nuclei re-emit the absorbed energy, again in the form of radio waves. This energy falls off over a short period of time. The re-emitted waves can be detected by a short-wave radio antenna.

The resonant frequency of stimulation of hydrogen nuclei is dependent on field strength. It is this relationship between the magnetic field strength and the resonant frequency of hydrogen nuclei which allows their localization. A magnetic field with a graded strength, will have nuclei resonating at different frequencies corresponding to the graded magnetic field strength. In this way the use of gradient magnetic fields allows for localization of hydrogen nuclei. Without the use of gradients, the entire anatomical region under examination would respond as a single entity and no localization would be possible.

To obtain information from a single slice of tissue it is essential to establish a gradient along the longitudinal (Z-axis) of the magnetic field from the foot-end of the magnet to the head-end. A radio wave frequency that corresponds to the resonant frequency of hydrogen nuclei and satisfies the Larmor relationship of a particular field strength in which a slice of tissue is located, is applied to the tissue. The tissue located in a specific magnetic field is stimulated and absorbs the transmitted radio wave energy. The absorbed energy causes the hydrogen nuclei to move from the Z-axis into the transverse (X-Y) axis. The degree of deflection depends on the amplitude of the radio wave applied. A radio wave with a small amplitude will only cause a small deflection of the precession, but larger amplitudes will produce $90^0$ or even $180^0$ of deflection. Tissue on either side of the slice will remain unstimulated and retain its longitudinal magnetization (Figure 1.15).

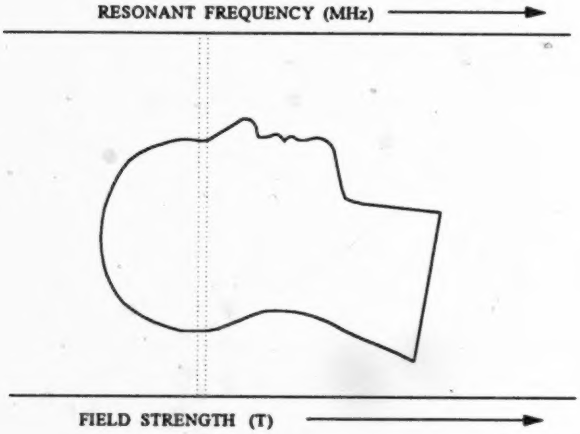

Figure 1.15: Slice Selection with Single Resonant Frequency Corresponding to a Single Plane

A single slice of tissue is localized in the way described above, but the signal immediately re-emitted from the slice gives no information regarding the structures present in the slice. To visualize these structures further encoding is necessary. A second phase encoding magnetic gradient is applied at right angles to the previously applied gradient.

The nuclei in the slice which originally resonated at the same frequency are now exposed to new magnetic fields of differing strengths. The interactions of the nuclei with the new local magnetic fields in each slice section will cause the nuclei to resonate at new frequencies (higher or lower) depending on their position in the transverse gradient. Again, the resonant frequencies of the nuclei are spatially encoded so that nuclei at one edge of the slice, in the weaker end of the gradient field, resonate at lower frequencies than those at the other edge, in the stronger field. The excited transverse section of tissue is sliced into parallel strips, the nuclei along any one strip resonating at the same frequency[223] (Figure 1.16).

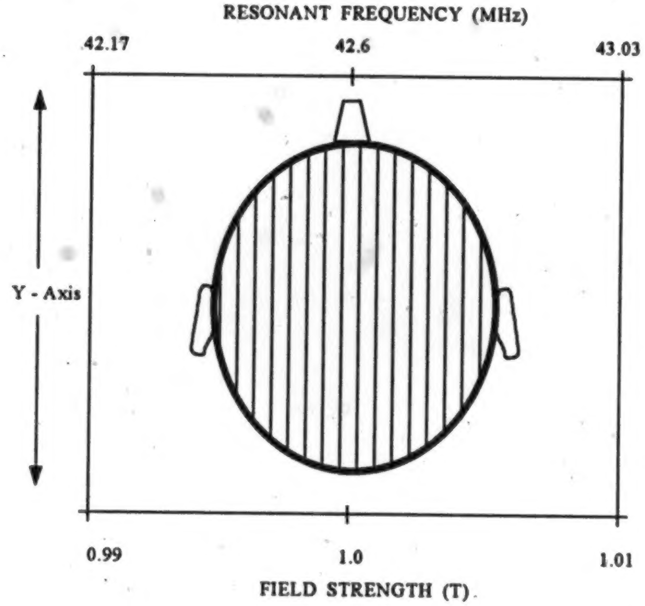

Figure 1.16: Nuclei in Parallel Rows have Same Frequency

The plane of tissue of interest is divided into parallel lines, each line radiating a specific frequency and intensity of radio wave. The strength of the radio signal measures the amount of hydrogen present, while the frequency gives the location of the line in the transverse slice of the tissue.

After the data from one pulse has all been recorded and stored the process is repeated, starting with the restoration of the Z-axis gradient. The same transverse slice of tissue is located and excited by radio frequency energy. Again the Z-axis gradient is turned off, and the transverse gradient is applied across the isolated slice of tissue, only in a slightly different direction. In this way the hydrogen concentration along a new set of parallel strips, slightly askew to the first set is measured. This process may be repeated many times, each time with the transverse gradient applied at a slightly different angle. Eventually the original slice of interest has a number of parallel lines, each set crossing the plane of the slice at a different angle.

Computer Fourier Transformation is applied to reconstruct a clinically useful picture from the data stored from the multiple parallel slices which traverse the original transverse tissue slice. These techniques map the concentration of hydrogen nuclei in different tissues. Unfortunately most living tissues have high concentrations of hydrogen, thus making use of this technique of tissue mapping alone provides little/ poor contrast between different tissues[222].

### 1.7.2 Tissue Characterization

Slice selection can be made utilizing the Larmor principle for tissue exposed to a particular magnetic field strength. Furthermore, the localization of proton density within different regions of the slice of tissue under investigation is determined by making use of gradient magnetic fields. Useful tissue information can be obtained using proton density and the principles of longitudinal and transverse relaxation, which provide tissue contrast.

Immediately upon removal of radio wave stimulation, the slice of tissue which has been excited begins to re-emit the absorbed energy in the form of radio waves. As this occurs the hydrogen nuclei within the tissue move from the transverse plane of stimulation back into the longitudinal plane. This regrowth of magnetization in the longitudinal plane is termed longitudinal, spin-lattice or $T_1$ relaxation. $T_1$ relaxation is the time required for approximately 63% of the remaining relaxation to reappear in the longitudinal plane. $T_1$

measures the rate of regrowth of magnetization in the longitudinal plane. The regrowth of magnetization in the longitudinal plane is partially due to the effect of distant magnetic fields of other nuclei on hydrogen nuclei. This process involves an exchange of energy between nuclear spins and the thermally activated motions of their surroundings.

The regrowth of magnetization back into the longitudinal axis of the magnet is not uniform for all tissues in a specified slice. Some regions of the tissue have a rapid regrowth of magnetization (short-$T_1$ tissues) compared to other regions. In tissue composed of predominantly water, the molecules move randomly, are not bound and collide frequently with one another. Random collisions transfer thermal energy within the surrounding matrix or lattice and it is precisely this thermal motion which facilitates proton realignment in the external magnetic field. Pure liquids have relatively long $T_1$ relaxation time, whereas tissue which is more solid has shorter relaxation time as molecules are less mobile, collide infrequently, but do facilitate proton realignment in the magnetic field. Thus in general, the more watery the tissue, the longer the $T_1$ relaxation time. In most tissues, $T_1$ is between 150-2000 milliseconds[222].

If the signal emitted after excitation is measured, it will be noted that the reduction in signal occurs long before the magnetization in the longitudinal plane has completely regrown. The reduction in signal is termed transverse relaxation, spin-spin relaxation or $T_2$. This effect is due to the random local variations in magnetic field strength as a result of thermal motion of particles, causing nuclei to dephase. Even though each nucleus still has a resonant frequency dependent on its surrounding environment, the interactions of the numerous emitted radio waves negate each other and produce the dephasing. $T_2$ is defined as the time it takes for dephasing to weaken the signal by 63%. $T_2$ relaxation is approximately 30 - 120 milliseconds for most tissues[222].

A third time constant, $T_2$*, is also important even though it is not strictly a relaxation parameter. $T_2$* is due to inhomogeneity in the strength of the externally applied magnetic field. This is a major source of dephasing in MRI due to slight variations in Larmor frequency of tissue as a result of field strength nonuniformity. This nonuniformity is constant and produces more dephasing than that caused by $T_2$. $T_2$* for normal tissues has a value of 1 - 10 milliseconds[222].

Immediately after excitation, the transverse component of the magnetization vector is long, signifying that the precessional phase coherence is high. Precessions are not canceling other precessions, but instead reinforce each other, so that the radio signal is strong. As the nuclei move out of phase, the transverse component shortens and the signal weakens. The re-emitted signal decays exponentially and is known as the free induction decay (FID). Different regions in the slice selected for investigation have different rates of decay of the signal with $T_2$ relaxation being shorter for solids than liquids. Solids have relatively fixed molecules with relatively fixed magnetic fields which cause significant spatial variation in the value of the local magnetic field around any given proton. In liquids, the local magnetic fields from neighbouring molecules fluctuate rapidly and randomly as molecules move about. They therefore average to a small value, sometimes zero, and contribute little to net magnetic field at any point. Therefore, the more watery the tissue, the longer the $T_2$ relaxation time.

Wide variation of $T_1$ and $T_2$ in normal and diseased tissues provides an excellent basis for tissue contrast. Various sequences and timing of radio wave stimulation may be applied to exploit the differences between tissues in imaging. These are termed Pulse sequences and are used to emphasize either the $T_1$ or $T_2$ differences between tissues under examination.

### 1.7.3 Pulse Sequences

As pointed out previously, there is a fundamental relationship between frequency of precession and applied magnetic field strength. In the case of the magnetic nucleus an appropriate equation for the Larmor frequency is:

$$\omega = \gamma B_o$$

where $\omega$ is the angular frequency of precession (called Larmor frequency), $B_o$ is the strength of the applied magnetic field and $\gamma$ is a constant (gyromagnetic ratio) for the particular nucleus[224].

The equation illustrates that it is possible to accurately control the angular orientation of nuclear magnetization by using suitable transmitter power (radio wave) and transmitter pulse length. The convention for describing the properties of the transmitter pulse is to ascribe to the pulse the angle through which the magnetization precesses during the pulse. For example, a pulse that tips the magnetization into the X-Y plane is called a $90^0$ pulse, whereas a pulse of twice the duration will place the magnetization along the Z-axis and is termed a $180^0$ pulse.

A $90^0$ pulse tips the magnetization into the transverse plane out of the longitudinal plane. The tissue now relaxes back into the longitudinal plane and re-emits signal (FID) which may be received by a radio antenna. If a second $90^0$ pulse is applied to the tissue when only a portion of the tissue has realigned with the longitudinal field there will be less hydrogen nuclei (magnetic moments) arranged parallel to the longitudinal axis to be re-excited back into the transverse plane. If the tissue is now re-excited and allowed to relax back, the re-emitted FID signal will be weaker. This phenomenon of tissue relaxation and pulse sequencing may be used to emphasize differences between tissues.

### 1.7.3.1 Inversion-Recovery Pulse Sequence

This pulse sequence may be used to display $T_1$ contrast. The subject is placed in the externally applied magnetic field and a radio wave is applied. The initial radio wave is applied for a sufficient duration of time to produce a $180^0$ pulse This has the effect of inverting the nuclear magnetization in the slice of interest. This pulse is followed after a time TI (inversion time) by a $90^0$ pulse. Proton magnetization aligned within the longitudinal magnetic field produces no signal. These protons have to be excited into the transverse plane by a $90^0$ pulse before a signal may be emitted. The signal emitted generates the proton FID signal.

After the $180^0$ pulse, the proton magnetization is pointing in exactly the wrong direction relative to the externally applied magnetic field. In time the protons in the various tissues start to dephase as they are no longer in equilibrium with their surroundings. Many of the protons turn around as a result of their interaction with their surroundings, and the magnetization recovers exponentially through zero back to its original equilibrium value, in a positive direction and parallel to the Z-axis. This is the process of longitudinal relaxation. The protons in each tissue relax with the particular value of $T_1$ for that tissue. Figure 1.17. illustrates the recovery for two tissues, one with a long $T_1$ and the other with a short $T_1$.

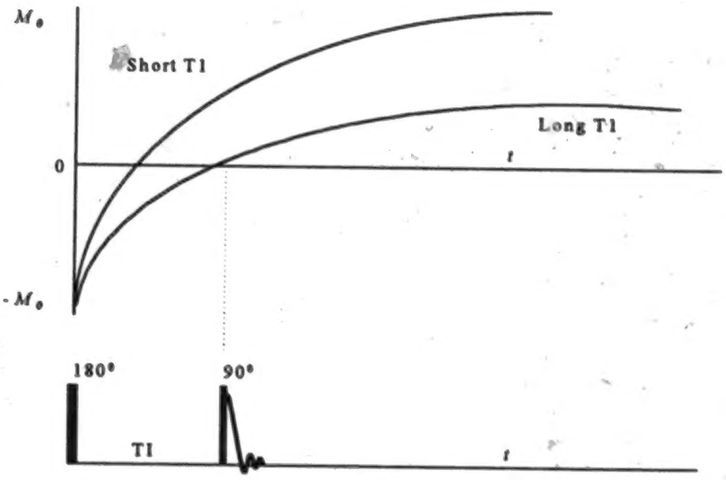

Figure 1.17: Inversion-Recovery Pulse Sequence

If after the application of the initial $180^0$ pulse, the second pulse ($90^0$) is applied at the exact time at which the magnetization of the tissue with the longer $T_1$ crosses the zero point, there will be no emitted signal from this tissue. The region on the image which represents this tissue will be black. On the other hand, the tissue with the shorter $T_1$ will have its magnetization largely regrown in the positive Z-axis and will have a correspondingly brighter signal. In this way $T_1$-weighted images are produced in which short $T_1$ components are brighter.

This pulse sequence can also be used to produce a bright signal for the long $T_1$ tissue by applying the second radio pulse ($90^0$) at the time at which the magnetization for the tissue with the short $T_1$ reaches zero. At this stage the long $T_1$ tissue has a large component of magnetization in the negative Z-axis, ensuring that an adequate number of protons are excited into the transverse plane, producing a bright signal for this tissue. This is also a $T_1$-weighted image[224].

### 1.7.3.2 Saturation-Recovery Pulse Sequence

This is another pulse sequence which emphasizes $T_1$-weighted images and consists of a series of $90^0$ pulses spaced at a time interval of TR (repetition time). If the repetition time between successive $90^0$ pulses is long compared to even the longest $T_1$ in the tissues, then after each $90^0$ pulse the nuclear magnetization will completely relax. In these instances the FID signal re-emitted after each pulse will have its full value from all elements of the tissue in the slice.

If the TR is however made comparable with $T_1$ for the shorter relaxation time components, these components will have time to relax almost completely, but the longer relaxation time components will have only just begun their exponential return to equilibrium. The signal produced for the short $T_1$ components of the tissue will therefore be strong (brighter image), while that for the long $T_1$ component is weak (darker image), with a dispersion of responses for tissues with intermediate values of $T_1$ in between

(Figure 1.18).

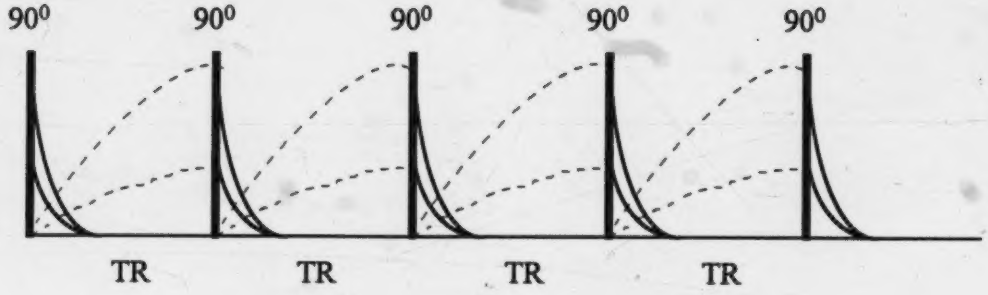

Figure 1.18: Saturation-Recovery Pulse Sequence

### 1.7.3.3 Echo Pulse Sequence

This pulse sequence can be used to generate $T_2$-weighted images. This sequence consists of a $90^0$ pulse followed at time $\tau$ by a $180^0$ pulse. After application of the $90^0$ pulse to tip the nuclear magnetic moments into the transverse plane, some nuclei will precess faster while some will precess slower than the average, due to field inhomogeneities. Application of a $180^0$ pulse at the end of the first delay period rotates magnetization about the X axis as shown in Figure 1.19. The fast spins are now behind the slow spins. During the second delay $\tau$, the fast spins catch up with the slow spins, thus refocussing the magnetization. This generates a spin echo at time $2\tau$, the time between the initial $90^0$ pulse and the echo is the Echo Time (TE) (Figure 1.20).

Some tissues have much longer $T_2$ than others. If TE is made comparable with the shorter $T_2$ values, the echo FID from these components will have substantially decayed, whereas those from the longer $T_2$ components will not. Tissues with longer $T_2$ will give a stronger signal, with a dispersion of responses from tissues with intermediate values of $T_2$. In this way a $T_2$-weighted signal is produced with tissue having long $T_2$ values appearing brighter in the image.

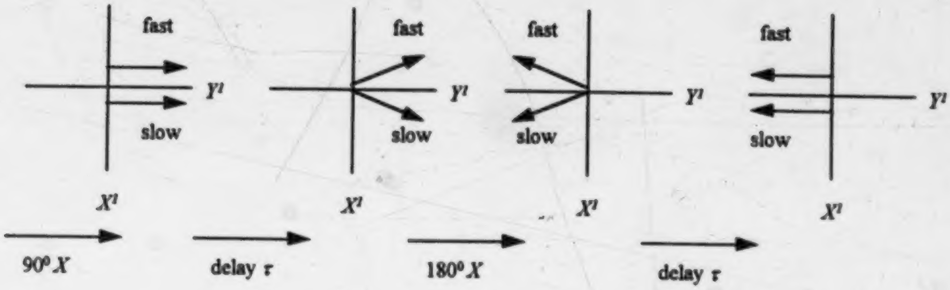

Figure 1.19: Spin-Echo Pulse Sequence Description

In general it is useful to maximize $T_1$- and $T_2$-dependent contrast with pulse sequences. To maximize $T_1$-dependent contrast, a value of TR is chosen that is about equal to the anticipated mean $T_1$ of the tissues of interest and TE is kept as short as possible to minimize the $T_2$-dependent contrast. In order to maximize the $T_2$-dependent contrast, TE is lengthened to the likely mean value for $T_2$ and the TR is made as long as practical to reduce the $T_1$-dependence. Spin-Echo sequence may be used in either the $T_1$-dependent or the $T_2$-dependent form.

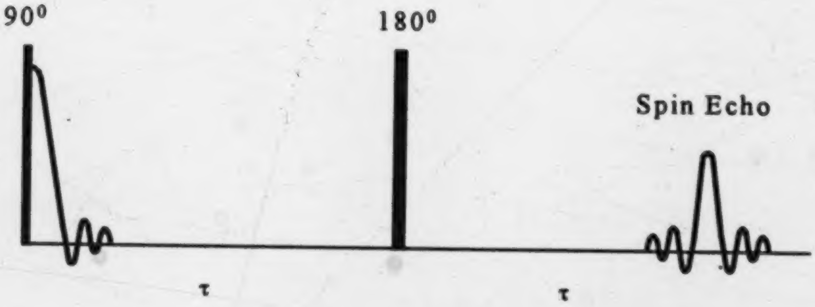

Figure 1.20: Spin-Echo Pulse Sequence

### 1.7.4 MRI Interpretation

The principles of magnetization of tissue have been applied to the temporomandibular joint to produce images of the joint and joint components[139,225,226]. Slices are selected by making use of gradient magnetic field strengths and spatial encoding occurs by further application of gradient fields. The proton densities in various regions of the joint are excited in order to sample the proton concentration specific to various tissues. Thereafter, the application of pulse-sequences to emphasize differences in tissue characteristics are applied to generate images with varying scales of dark and brightness. Generally, images which are produced with a short TE and a short TR will be $T_1$-weighted, whereas a long TE and a long TR will produce an image with more $T_2$-weighting. The images can now be interpreted, keeping in mind, the tissue characteristics which have been emphasized with the specific pulse sequence.

On $T_1$-dependent images of the TMJ the cortical bone covering the external surfaces of the condyle, posterior surface of the articular eminence and mandibular fossa appear as black lines (Figure 1.21). The cortical bone contains protons, but they are not capable of producing signal, since they are effectively immobilized in the rigid osseous structure. The effective proton density within cortical bone is therefore minimal. In contrast, the medullary space in bone contains a complex arrangement of bony trabeculae, fat, lymphatics, blood, blood vessels and extracellular ground substance. The mobile proton density of the marrow spaces is high and this tissue has short $T_1$ values. If saturation-recovery pulse sequences are applied, the tissue in the marrow space will essentially be relaxed by the time the next $90^0$ pulse is applied, producing a relatively bright signal corresponding to this tissue[227,228].

Muscle may also be identified on MR images and appear as an intermediate gray signal divided by darker bands of fascia. The organization of muscle tissue is more complex, numerous protein macromolecules are present and the mobile proton density is reduced.

MR images of the temporomandibular joint show the lateral pterygoid muscle inserting into the fovea on the anterior surface of the condylar neck (Figure 1.22). Anteriorly, the muscle fans out to gain attachment to the pterygoid plates. Coronal slices of the joint will image the body of the masseter muscle lateral to the ramus, and the medial pterygoid medial to the ramus (Figure 1.23). Therefore, muscle may be differentiated from other tissues in the orofacial region by utilizing MRI.

The articular disc interposed between the cortical surfaces of the articular structures is clearly defined as a bow-tie structure which is somewhat darker than muscle, but lighter than cortical bone (Figure 1.21). The disc is composed of a regular fibrous collagen meshwork with charged proteoglycans interspersed. The proteoglycans attract and trap synovial fluid which contains nutrients, metabolites, ions and water. The disc has a longer $T_1$ than muscle and is therefore proportionately darker. In instances where the disc is displaced and morphological changes of the disc and its attachments have occurred, the signal emanating from the disc may be altered. The disc and its posterior attachments may appear darker than in the healthy state due to the loss of proteoglycans and fluid, and increased fibrosis which may take place[228].

Surrounding the osseous articular surfaces and the disc is synovial fluid which is contained in the superior and inferior joint spaces. The synovial fluid bathes the articular structures and penetrates the disc as well as the fibrocartilage covering the osseous articular surfaces. Small accumulations of synovial fluid may be present in the anterior or posterior joint cavity recesses, depending on the position of the condyle. Synovial fluid is composed largely of plasma which diffuses through the synovial membrane, although large macromolecules such as hyaluronic acid and proteoglycans are also secreted into the joint space. On $T_1$-dependent images the synovial fluid appears bright and effectively separates the disc from the osseous articular structures[227,228].

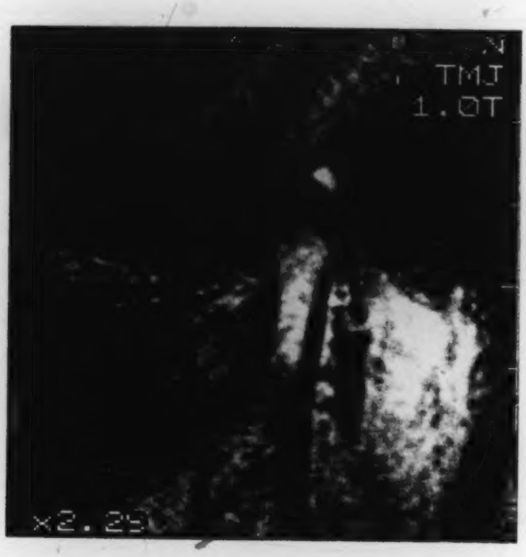
TMJ
1.0T
x2.25

Figure 1.21: Sagittal MRI of the TMJ

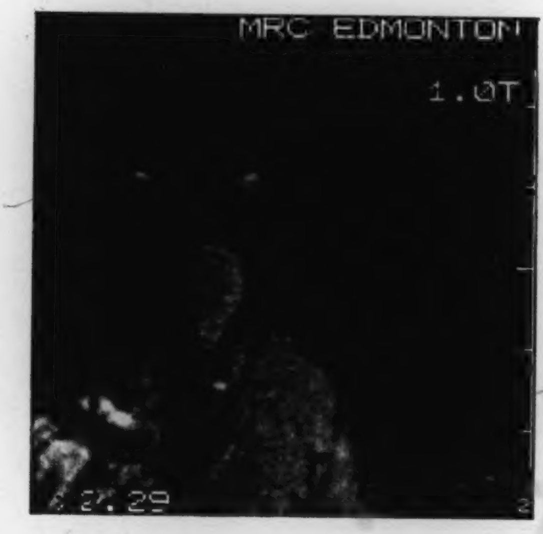
MRC EDMONTON
1.0T
2.29

Figure 1.22: Sagittal MRI of TMJ and Lateral Pterygoid Muscle

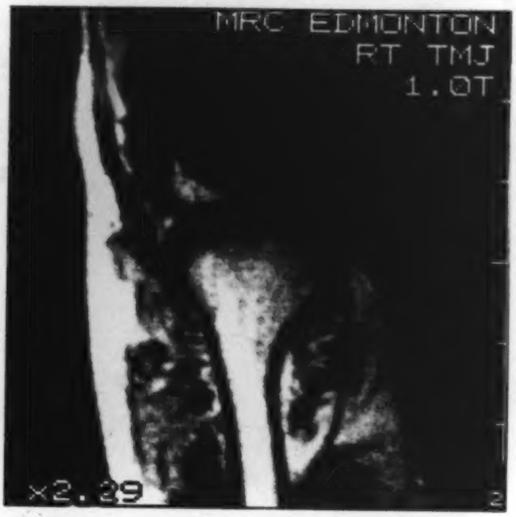
MRC EDMONTON
RT TMJ
1.0T
x2.29
2

Figure 1.23: Coronal Closed Mouth MRI of the TMJ

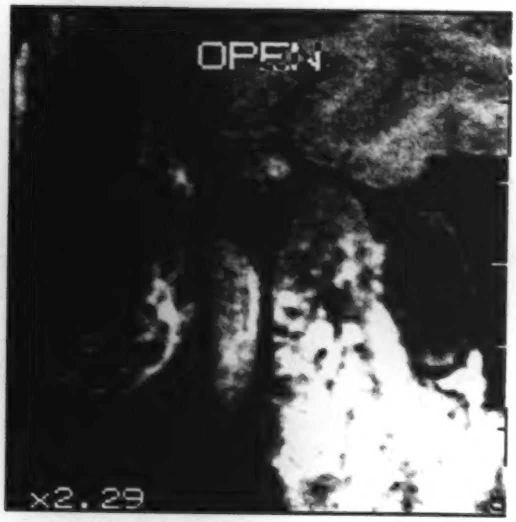

Figure 1.24: Sagittal Open Mouth MRI of the TMJ

The retrodiscal tissues and posterior disc attachments may also be defined on MR images. The superior and inferior posterior attachments of the disc are clearly defined on $T_1$-weighted images, especially in the mouth-open position. The elastic fibers of the superior attachment and the dense collagenous fibers of the inferior attachment exhibit similar contrast to that of the posterior band of the articular disc (Figure 1.24). They therefore appear dark on $T_1$-weighted images and are clearly contrasted against the retrodiscal tissue which has a brighter signal. The bright signal emanating from the retrodiscal tissue is due to adequate vascularity and rich fat deposits in this region.

In the event of disc displacement and elongation of the posterior discal attachments, the retrodiscal tissues and posterior attachments become interposed between the functional osseous articular surfaces. In time these tissues are altered to assume the function of the displaced disc. The retrodiscal tissues become fibrosed and collagen is laid down in a more regular arrangement. The retrodiscal tissue may then resemble the articular disc and appear darker on MR images. This can lead to a false-negative identification of disc displacement if the anterior joint compartment is not examined for the presence of discal structures (Figure 1.25, Figure 1.26).

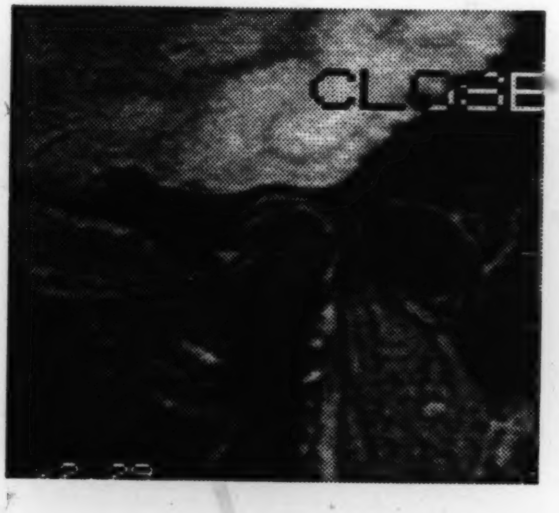

Figure 1.25: Sagittal MRI showing Posterior Attachment Remodeling with Disc Displacement

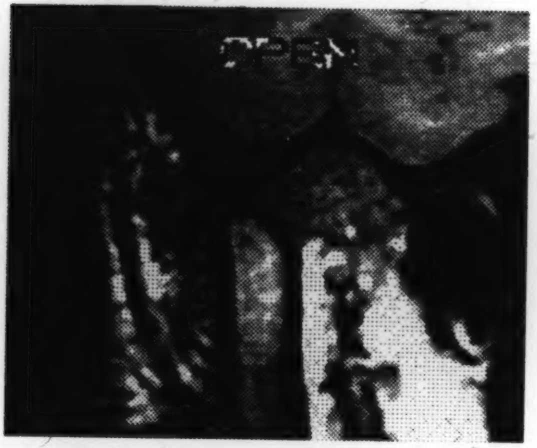

Figure 1.26: Sagittal Open Mouth MRI of the TMJ with Anterior Disc Displacement

### 1.7.5 Summary

Magnetic resonance imaging of the temporomandibular joint has been shown to be a valuable imaging modality. This technique is not only capable of identifying the soft tissue structures of the joint but is also capable of assigning tissue characteristics which provide additional important information regarding joint pathology and disc status. The presence of joint inflammation associated with disc displacement may be identified, as well as chondroid metaplasia that occurs in the disc secondary to its displacement[228,229]. Further technological advancements in MRI and receiver coil specificity should enhance the detail currently available on images of the TMJ. It is hoped that within the foreseeable future the fibrocartilage covering the osseous surfaces may be clearly defined and that quantification of disc fluid will be possible. These developments will greatly advance the understanding of the pathophysiology of disc displacement and joint arthritides.

## 1.8 Cephalometrics

In this section the general principles of cephalometrics will be introduced which will enable the reader to grasp the applications of this technique in orthodontic evaluation of patients and its application in research. Commonly used cephalometric landmarks will be identified and defined. The error associated with the identification of cephalometric landmarks and measurement of cephalometric variables will be discussed. Finally, the point should be made that despite the limitations of cephalometrics, with standardization and careful appraisal, it is a valuable research tool.

### 1.8.1 General Principles

Cephalometrics is based on the principles of craniometry, which has been used in anthropology for the quantitative study of skulls. Cephalometric radiology is a method employed to produce either lateral or frontal images of a subject's head with the subject in a fixed and reproducible head position. The subject's head is held in a fixed position in a cephalostat by means of ear rods. The ear rods are aligned on the central axis of radiation from the x-ray source. For the lateral views of the skull and face, the sagittal plane of the head is at right angles to the direction of the x-rays and parallel to the plane of the radiographic film (Figure 1.27). The distance from the x-ray source to the mid-sagittal plane of the skull, as well as the distance to the radiographic film are standardized to produce images with the greatest clarity and the least magnification distortion. Standardization of head position with constant source-object-film distances permits repeat measurements with good reproducibility[230].

The most widespread application of cephalometric radiography and cephalometric measurements has been by orthodontists in diagnosis, treatment planning and evaluation of treatment results. Cephalometric landmarks are used to define cephalometric planes, angles and linear dimensions necessary to quantify soft and hard tissue regions of the face. These measurements are used for cross-sectional evaluation of individuals of similar age, sex and racial backgrounds to identify differences that may occur between groups of individuals exposed to various environmental or growth modifying factors. A single radiographic film provides only a static evaluation of an individual's size and shape at that point in time.

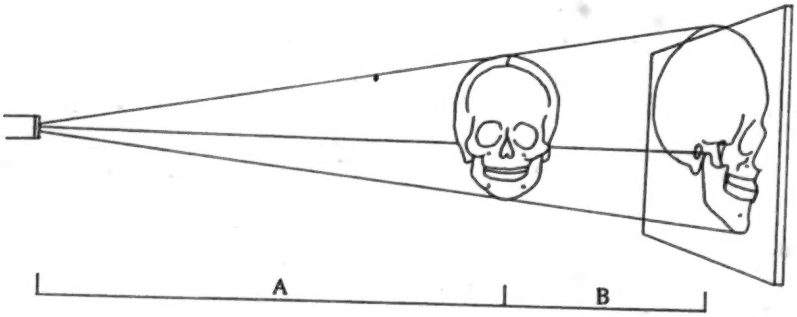

Figure 1.27: Lateral Cephalometric Radiography

(A: distance from x-ray source to mid-sagittal plane of object; B: distance from mid-sagittal plane of object to film)

Longitudinal cephalomeric radiographic evaluation of facial changes can be carried out when subsequent standardized head films of the same individual are produced. This information provides insight into the magnitude and direction of growth in various facial skeletal components during development. Major databases such as the Michigan growth study[231], the Burlington growth study[232], the Bolton study[233], and several other smaller growth studies have been established making use of standardized head films. These studies resulted in the publication of population norms for cephalometric measurements. These norms are used in clinical orthodontic practice to determine the extent of deviation of a facial region from some set standard. The norms are usually calculated means and are published with an associated standard deviation. In clinical practice, this standard deviation is used to determine the acceptable range of variability of a facial region under consideration. Norms are however subject to considerable variation due to environmental, biological and genetic variation and should be interpreted with this in mind.

### 1.8.2 Application of Cephalometrics

Cephalometrics is routinely utilized in orthodontics for the diagnosis and treatment planning of individuals with alterations in facial morphology and malocclusions. Angular and linear measurements produced on lateral cephalometric radiographs permit the relationships between the osseous, dental and soft tissue components of the face to be assessed. This evaluation provides information on the vertical and sagittal dimensions of the face. Antero-posterior radiographs provide information on the transverse dimensions of the face that cannot be appreciated on two-dimensional lateral cephalometric radiographs.

Longitudinal assessment of radiographs allows the observer to evaluate changes in the face that have occurred over a period of time. In the growing individual much of the change in size and proportion is growth related. The changes may be assessed to determine whether the direction and magnitude of growth is in keeping with the development of facial harmony and balance. Other observed changes may be related to treatment effects or the result of environmental influences on normal growth and development.

Cephalometrics has been applied and investigated extensively in the orthodontic literature. Its application in research will be discussed here and will be followed later in this section by investigations into the technique.

In orthodontics or orthognathic surgery, stability of treatment results, improved function, health and esthetics are considered essential for adequate treatment. Stability of results are adequately assessed making use of lateral cephalometric radiography. Skeletal and dental relationships have been evaluated over time to assess the stability of treatment. Lateral cephalometrics are used to assess esthetic changes associated with treatment and the stability of these changes. In particular the soft tissue drape in the lower third of the face is evaluated to assess changes related to orthodontic therapy[234-236] while more extensive soft tissue changes involving the nasal tip and lower face are evaluated with cephalometrics to appraise orthognathic surgical results[237,238].

The extraction, non-extraction orthodontic dilemma was studied making use of lateral cephalometric radiographs to investigate the changes in soft tissue drape with these two forms of orthodontic treatment. In these evaluations the skeletal structures, the dentition and the soft tissues were investigated to determine the effects of the various forms of treatment[239,240].

Various factors such as mouth-breathing[123,124], facial trauma[134] and inherited facial deformities[84] have been studied to determine the effects of these factors on facial development. Cephalometric measurements were able to identify alterations in facial morphology compared to norms and were used to localize and measure the extent of the facial deformity.

### 1.8.3 Cephalometric Landmarks

Many cephalometric landmarks used today were previously defined and used in anthropological measurements of dry skulls. The landmarks are typically located on the external osseous surface since these points are less likely to have other bony structures superimposed and are clearly identified on lateral cephalometric radiographs. The most widely used cephalometric reference landmarks and planes are illustrated in Figure 1.28 and defined and listed below in Table 1.1. Tables 1.2 and 1.3 contain linear and angular cephalometric measurements respectively.

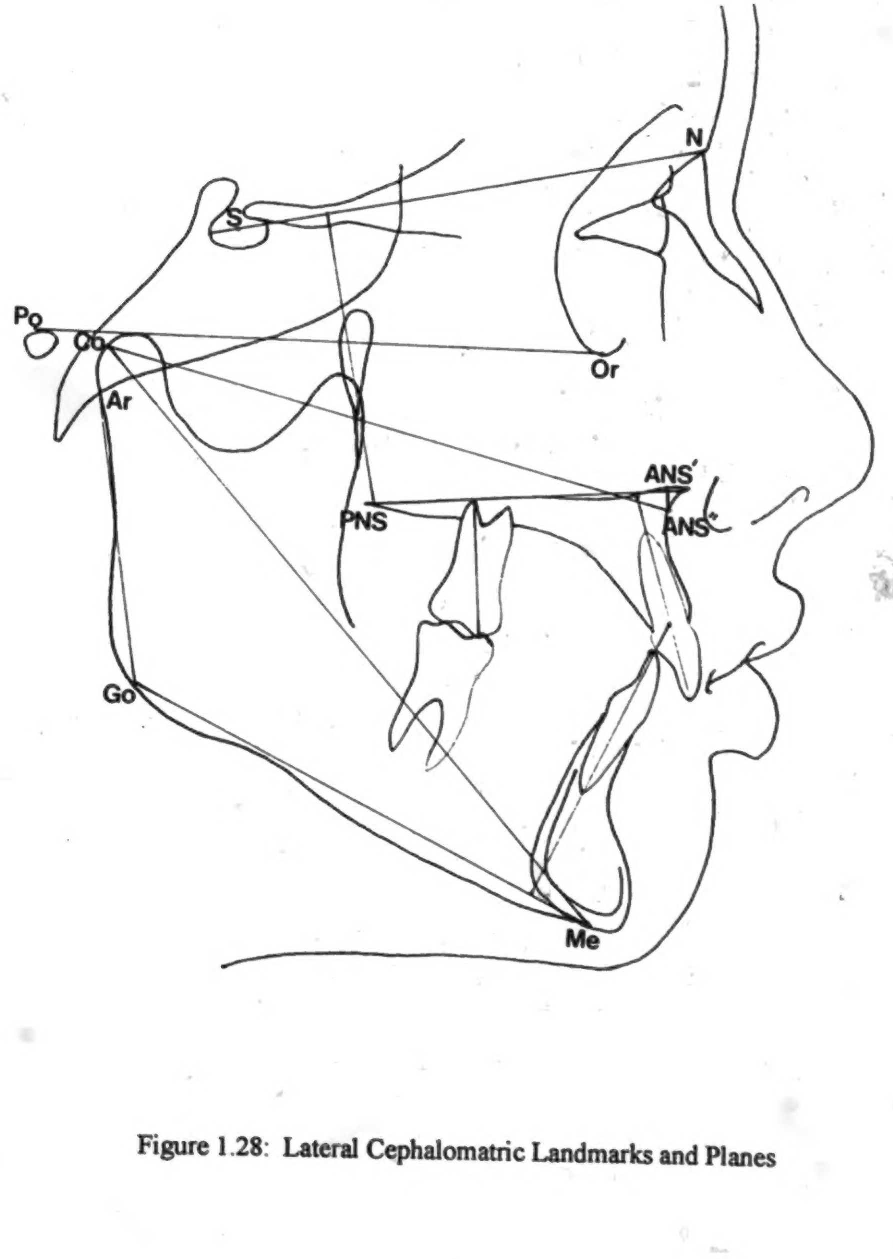
N
S
Po
Co
Or
Ar
ANS'
PNS
ANS*
Go
Me

Figure 1.28: Lateral Cephalomatric Landmarks and Planes

| Cephalometric Abbreviation | Definition of Landmarks and Planes |
|---|---|
| ANS | Anterior nasal spine - Tip of median bony process of the maxilla at lower margin of anterior nasal opening |
| ANS' | A point on upper contour of ANS where vertical thickness is 3 mm |
| ANS" | A point on lower contour of ANS spine where vertical thickness is 3 mm |
| Ar | Articulare - intersection of inferior cranial base surface and the averaged posterior surfaces of the mandibular condyles |
| Ba | Basion - most inferior, posterior point on anterior outline of foramen magnum |
| Co | Condylion - most postero-superior point on bony outline of the average right and left condylar head |
| Gn | Gnathion - most antero-inferior point on outer bony symphysis of mandible |
| Go | Gonion - most postero-inferior point on bony angle of average left and right mandibular outlines |
| LIA | Lower Incisor Apex - the root apex of mandibular central incisor |
| LIT | Lower Incisor Tip - the incisal tip of the mandibular central incisor |
| Me | Menton - most inferior point on bony outline of mandibular symphysis in midsagittal plane |
| N | Nasion - Junction of frontonasal suture at most posterior point on curve at the bridge of the nose |
| Or | Orbitale - most inferior point on bony outline of averaged inferior orbital rims |
| Pg | Pogonion - most anterior point on outer cortex of bony symphysis of mandible |

| | |
|---|---|
| PNS | Posterior nasal spine - most posterior projection of bony contour of palate |
| Po | Porion - most superior point on bony outline of external auditory meatus |
| Ptm | Pterygomaxillary fissure - most postero-superior point on the average right and left bony outlines of pterygomaxillary fissure |
| S | Sella - center of pituitary fossa of sphenoid bone as identified by visual inspection |
| UIA | Upper Incisor Apex - the root apex of the maxillary central incisor |
| UIT | Upper Incisor Tip - the incisal tip of the maxillary central incisor |
| ANS - PNS | Palatal plane - plane formed by connecting ANS point and PNS point |
| Go - Me | Mandibular plane - plane formed by connecting Go and Me points |
| FH | Frankfort Horizontal - plane formed by connecting Or and Po |
| LI | Lower Incisor - line formed by joining LIA to LIT |
| OP | Functional occlusal plane - a plane drawn through points of contact between the first permanent molar and first and second premolars (or of deciduous molars) |
| SN | Sella-Nasion - plane formed by connecting S and N points |
| UI | Upper Incisor - line joining UIA to UIT |

Table 1.1: Cephalometric Landmarks and Planes

| Abbreviation | Description |
|---|---|
| SN | Sella - Nasion |
| S-Ba | Sella - Basion |
| S-Co | Sella - Condylion |
| S-Ar | Sella - Articulare |
| S-Go | Sella - Gonion |
| SN-PNS | Posterior Nasal Spine perpendicular to Sella - Nasion plane |
| Ba-N | Basion - Nasion |
| N-ANS | Nasion - Anterior Nasal Spine |
| ANS-Me | Anterior Nasal Spine - Menton |
| N-Me | Nasion - Menton |
| 6/ANS-PNS | Maxillary mesiobuccal cusp tip perpendicular to palatal plane |
| Ptm-ANS | Pterygomaxillary fissure point inferior - Anterior Nasal Spine |
| Co-Go | Condylion - Gonion |
| Ar-Go | Articulare - Gonion |
| Co-Me | Condylion - Menton |
| Ar-Me | Articulare - Menton |
| Go-Me | Gonion - Menton |
| LIT/Go-Me | Lower Incisor Tip perpendicular to Gonion - Menton plane |

Table 1.2: Linear Cephalometric Variables

| Name | Description |
|---|---|
| N-S-Ba | Nasion - Sella - Basion |
| SN/Ar-Go | Sella - Nasion/ Articulare - Gonion |
| FH/Ar-Go | Frankfort horizontal/ Articulare - Gonion |
| FH/Co-Or | Frankfort horizontal/ Condylion - Orbitale |
| BaN/Ptm-Gn | Basion - Nasion/ Pterygomaxillary point - Gnathion |
| UI-LI | Upper Incisor/ Lower Incisor |
| LI/Go-Me | Lower Incisor/ Gonion - Menton |
| UI/ANS-PNS | Upper Incisor/ Anterior Nasal Spine - Posterior Nasal Spine |
| Ar-Go-Me | Articulare - Gonion - Menton |
| SN/ANS-PNS | Sella - Nasion/ Anterior Nasal Spine - Posterior Nasal Spine |
| SN/Go-Me | Sella - Nasion/ Gonion - Menton |
| FH/Go-Me | Frankfort horizontal/ Gonion - Menton |
| ANS-PNS/Go-Me | Anterior Nasal Spine - Posterior Nasal Spine/ Gonion - Menton |

Table 1.3: Angular Cephalometric Variables

Cephalometric landmarks have been chosen for clarity, reproducibility and because they are used to determine the dimensions or position of various regions of interest. Landmarks in cephalometrics are typically defined in three different ways (Figure 1.27):

- The cephalometric landmark is located at the confluence of one or more bones. The confluence may be marked by a suture system or the projected intersection of bony outlines. Examples of these are: Nasion (N), which is located at the confluence of the nasal bones and frontal bone on the external surface of the skull; Articulare (Ar), intersection of the ventral surface of the basilar part of the occipital bone and posterior border of the mandibular ramus[231].
- Landmarks may be located in the centre of a structure which may not necessarily be

osseous, but is readily defined and reproducible. Such a landmark is Sella (S) which is located in the centre of the sella turcica above the body of the sphenoid[231].

- Cephalometric landmarks on external bony surfaces are defined by virtue of their position on the most convex or concave surface of the bone. Pogonion (Pg) is defined as the most convex point on the anterior surface of the bony symphysis of the mandible, while B point and A point are defined as the most posterior concave points on the anterior surface of the mandible and maxilla respectively[231].

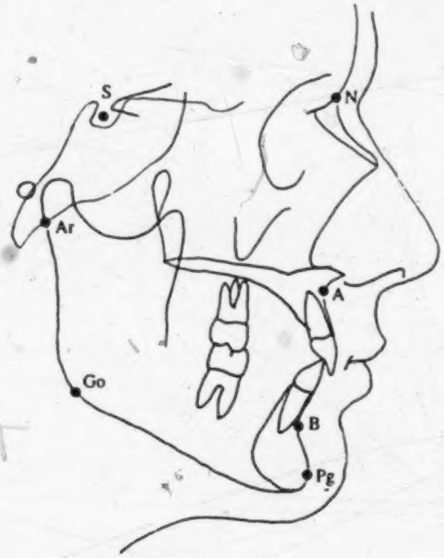

Figure 1.29: Cephalometric Landmark Identification

(S: sella; N: nasion; Ar: articulare; A: A point - subspinosum; B: B point - infradentale; Go: gonion; Pg: pogonion)

Lateral cephalometric landmarks may be located on, or near the midsagittal plane of the skull, such as Nasion (N) and Sella (S). Linear measurements between any of these landmarks correspond well with the actual anatomic length of the structure measured provided the projected magnification is considered. Other landmarks are located lateral to the mid-sagittal plane, eg. Gonion (Go) and Articulare (Ar). Measurements between any of these landmarks are distorted due to projection magnification but remain well correlated to actual anatomical measurements once magnification errors are corrected.

Cephalometric planes or measurements which are formed by a line connecting two cephalometric landmarks not located in the same sagittal plane of the face may not represent the actual anatomical linear length between the two landmarks. A landmark located lateral to the midsagittal plane joined to one in the midline has an oblique orientation. The projected length of this linear measurement is shorter than the anatomical measurement between these two points. An example is the linear measurement of the mandibular corpus. This linear measurement is formed by measuring between Gonion (Go), laterally placed relative to mid-sagittal structures and Pogonion (Pg), situated on the mid-sagittal plane of the skull.

Measurement corrections have been attempted using radiographs in another plane, such as antero-posterior cephalometric radiographs. These attempts have however only been able to identify a few landmarks common to both lateral and anteroposterior views[241]. Three-dimensional reconstruction of radiographic images may lend itself to determination of actual anatomic linear measurements. Unfortunately, cephalometrics is limited by its two-dimensional representation of the three-dimensional facial skeletal structures, which does not make all measurements possible.

### 1.8.4 Cephalometric Error

All sources of error associated with cephalometric radiography need to be considered when cephalometric measurements are made. Sources of error produced by landmark identification, measurement technique, subject positioning in cephalostat in addition to magnification and projection errors can contribute significantly to making the cephalometric evaluation meaningless. For this reason error in cephalometric measurement needs to be controlled so that real effects of growth, treatment or some other form of intervention may be monitored. If the measurement error is large, the actual effect the observer wishes to determine due to treatment or intervention may not be evident. A number of factors contributing to cephalometric measurement error have been identified.

### 1.8.4.1 Quality of Images

Quality of radiographic images is influenced by the choice of radiographic film and the radiation exposure. Every effort is made to obtain films of high quality and good structural definition. A conflict exists between radiation control and the choice of film quality. Fast films and rare-earth intensifying screens significantly reduce the exposure to radiation but produce poorer definition than slower films and high-definition screens. Random errors can arise as a result of variations in film density and sharpness of images[242].

### 1.8.4.2 Projection Errors

Two types of projection errors have been identified. The first is a result of the x-ray beam being non-parallel and originating from a very small source. Depending on the distance between the source of the radiation beam, the object of interest and the film, varying degrees of object magnification will be produced when an image is generated[243,244]. To correct for this problem, the degree of magnification must be considered when comparisons are made between two groups of images obtained with different radiographic equipment. Magnification errors can be readily adjusted to avoid systematic errors.

The second type of projection error occurs when cephalometric measurements have defining points that do not lie in the plane parallel to the film. In these instances linear and angular cephalometric measurements are distorted. Linear measurements are foreshortened relative to the actual anatomic dimension. In general, projection lengths are compared without compensation, which can be misleading, especially when there are variations in lateral positioning of landmarks relative to mid-sagittal landmarks between individuals being compared.

### 1.8.4.3 Subject Positioning

Random errors may be introduced as a result of variations in positioning of the patient in the cephalostat[242]. Rotation of the head from side to side or along the long axis of the neck may produce projection errors. Rotations of up to $5^0$ from the standard head position result in length measurement errors of less than one percent. Rotations of more than $5^0$ may increase the error. Generally, rotations of greater than $5^0$ are clinically detectable when positioning the subject and can be avoided[244].

Another source of error may be introduced if the alignment of the cephalometric system is not ideal. The cephalostat and the film can be rotated with respect to one another or an anatomic variation in the position of the external acoustic meati may result in head rotation, introducing a rotational error[242].

### 1.8.4.4 Repeat Imaging

Since errors may be introduced with positioning of the patient, it is questionable whether a repeat radiograph will produce the same representation of the skeletal structures. This was tested by a number of observers where duplicate radiographs were available and the errors between tracings from separate radiographs were calculated[230,245,246]. The results of these studies show that the error variance was greatest from the repeat tracings and that the random error introduced in obtaining repeat cephalometric radiographs was negligible[230,245,246]. Therefore error introduced in landmark identification on the radiographs was greater than error introduced by repositioning the subject and re-imaging.

### 1.8.4.5 Landmark Identification

The greatest contribution to error in measurement is due to inconsistent landmark identification. Precise definition of landmarks assist in reducing the systematic error in interpretation of landmark position. Landmarks have a characteristic envelope of identification error[247,248]. Some landmarks may have other bony structures superimposed which makes the identification difficult[243]. Landmarks located on the outer contour of osseous surfaces also exhibit a margin of error, despite being free of superimposition of other osseous structures. These landmarks are defined as the most anterior or posterior point on the bony curvature and may vary depending on the orientation of the radiographic image[242,249].

Repeat tracing and measurement of landmarks and cephalometric variables reduces the random error of measurement. Direct digitization is less tedious but is no more accurate than digitization of the tracings made[250]. The major source of error is in landmark identification, and not the method chosen to select the landmark[246].

The precise definition of landmarks can aid in reducing sytematic error. A set of criteria defining landmarks will prevent the observer's practice from changing with experience. Definition of landmarks may also aid in improving inter-rater reproducibility when more than one observer is used to measure the radiographs[242].

#### 1.8.4.6 Tracing Facilities

There is little point in having radiographs of high quality if they are measured in bright ambient lighting or if tracings are made on poor quality tracing paper[242]. By convention, tracing paper of 0.003 inch thickness is used with a 0.03 diameter lead pencil to ensure sharp detail in tracing.

### 1.8.5 Summary

Cephalometric radiology has emerged as a valuable research tool allowing quantification of facial changes related to normal growth and development, orthodontic intervention or orthopaedic treatment, environmental factors or congential facial abnormalities. Longitudinal studies have greatly enhanced our knowledge regarding rotational mandibular growth in various facial growth patterns and has provided insight into compensations which may occur as a consequence of altered growth potential.

A number of factors have been identified that contribute to cephalometric measurement error. When factors such as standardization of radiographic-cephalometric technique are adequately controlled, the variability of the technique is significantly reduced. Other factors are consistently monitored to ensure good quality of radiographs and accurate measurement of cephalometric variables. Not all factors contributing to random error can be controlled for. Instead, they may be minimized so that the effect of these errors on radiographic interpretation and measurement is insignificant in relation to the overall variability between subjects.

## 1.9 Statement of the Problem

The interaction of genetic, paracrine, hormonal, neural and muscular factors influence the growth and development of facial regions. The extent to which any one of these factors dominates the development of a single region is debatable, but the fact that all are necessary to maintain harmonious development is widely accepted. Growth and expansion of tissue in one region of the face has an effect on other regions which are in direct communication, or which function in unison with one another. Petrovic suggested a cybergenic model to emphasize the interactions of various tissues in facial development[251]. This model encompasses interactions between the local functional environment, produced by changes in maxillary position with growth, as well as neural, muscular, connective tissue and hormonal influences. Petrovic and co-workers[16] showed that these factors were of importance in determining the extent and direction of condylar growth contribution to mandibular development.

A number of factors have been shown to disturb the local functional equilibrium of the oral region[95,108-111,125]. Some of these disturbances act at a local level within the TMJ and interfere with the normal functional harmony of the joint, and also influence other regions of the face as a result of muscle function adaptations. On the other hand, altered muscle function may have a direct effect on bones at sites of muscle insertion or attachment, or an indirect effect on the maintenance of tissue of the TMJ[136]. These local environmental factors influence the magnitude and direction of growth in the two major areas contributing to enlargement of the mandible, namely the condyle and mandibular ramus.

Histological and functional changes within the joint following disc displacement have been shown in numerous animal[252-254] and human studies[26,173,212,255]. These changes are not localized to the articular disc and involve the functional articular components of the joint, the synovial membrane, synovial fluid and non-articular tissues. These histological and functional changes within the joint can be considered as yet another local alteration in the functional environment of the joint.

Numerous studies have observed signs and symptoms associated with disc displacement, or have directly observed disc displacement in the adolescent population[4,9,10,188,256]. If disc displacement is considered to be a localized alteration in the functional environment of the TMJ, then disc displacement may be associated with localized alterations of the condyle's contribution to facial development. To date the associations between disc displacement of the TMJ and facial morphology in an adolescent population has not been adequately investigated.

Evidence of associations between disc displacement and facial morphology would be of paramount importance to the clinician diagnosing and treatment planning individuals with alterations in facial morphology. This information may suggest an altered treatment approach suited to the joint dysfunction identified. Furthermore, the prevalence of internal derangement in adults presenting with TMJ disorders and facial pain has been shown to be 82%[8]. Early identification of these individuals, during adolescents, by means of clinical signs and symptoms or facial features may permit earlier identification and prophylactic management where appropriate.

In summary, disc displacement has been identified in the adolescent population and can be considered to be a localized alteration in the functional environment of the joint which may be associated with altered development of the condyle and mandible. Associations between disc displacement and facial morphology in the adolescent population are inadequately presented and require further investigation.

### 1.9.1 Research Hypotheses and Questions

The aim of this body of work is to determine if associations exist between disc displacement and altered facial morphology in an adolescent population. In this study MRI interpretation of disc position will be utilized to test the following hypotheses:

1. **Reproducible quantification of MRI determined TMJ disc position is not possible.**
2. **There is no association between TMJ disc displacement and adolescent facial morphology.**
3. **Alteration in mandibular morphology is most strongly associated with TMJ disc displacement.**
4. **Clinical signs and symptoms are unable to predict MRI determined disc status.**

From the hypotheses the following research questions arise:

1. **How reproducible is magnetic resonance imaging in determining disc status?**

Magnetic resonance imaging of the temporomandibular joint has shown excellent contrast and resolution of joint structures. Moreover, the technique is non-invasive and does not require the introduction of contrast fluid into the joint to identify the soft tissue articular disc. To date the interpretation of disc position has relied on subjective evaluation which has been shown to be highly reproducible, but does not provide an adequate measure of quantification of disc status. A technique for quantification of disc status will be investigated to provide continuous data for disc status evaluation. It is hoped that the quantification of disc information from all regions of the joint, free of subjective interpretation of selected slice images of the joint, will provide an unbiased and accurate representation of TMJ disc status.

**2. What is the association between disc displacement and facial morphology?**

A number of factors have been identified which influence the development of the growing mandible. In particular, factors classified as local environmental factors have a great impact on condylar cartilage development. Factors such as local inflammation, trauma, and altered muscle function seem to reduce the contribution of the condyle to vertical development of the ramus. Therefore, if disc displacement is considered to be a localized alteration in the functional environment of the joint, is it possible that disc displacement is associated with altered facial morphology in an adolescent sample.

**3. Which regions of the face are most affected by disc displacement?**

The various regions of the face will be investigated to determine if a single region shows greater association with disc displacement than other regions. Localized alterations and adaptations in facial regions may shed light on the pathophysiology of disc displacement as well as the extent of involvement expected. Localized alterations in facial morphology associated with a specific factor is of great diagnostic and prognostic value to the clinician treatment planning subjects with altered facial morphology and malocclusions.

**4. What is the value of a clinical investigation in determining joint status?**

The clinician is the first to evaluate individuals presenting with signs and symptoms associated with disc displacement. The presenting subjective characteristics and clinical findings of disc displacement need further investigation to determine their relevance to the organic disorder. Signs and symptoms strongly associated with disc displacement need to be identified and differentiated from the presenting features of other craniofacial pain disorders. This will aid the clinician in making more accurate diagnostic decisions and implementing more effective treatment approaches. Magnetic resonance imaging of the TMJ may help to determine which clinical signs and symptoms are associated with disc displacement and whether patterns of signs and symptoms occur with increased severity of disc displacement.

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# CHAPTER 2

## A Pilot Study: TMJ Internal Derangement and Adolescent Craniofacial Morphology.

### 2.1 Introduction

Craniofacial morphology is the study of the dynamic relationship of the various facial skeletal components relative to one another during development. Numerous theories have been advanced to explain facial growth and development[1-5]. Principles that apply to one area of facial growth may however not apply to another. Mandibular development is no less complex, and in particular, controversy rages concerning the role of the condylar cartilage in development of the mandible. Mandibular development is of particular interest to the orthodontist in treatment planning. The effects of orthopedic forces on the condylar cartilage for growth modification is highly controversial. It has been suggested that condylar cartilage growth may either be stimulated or inhibited by the application of functional orthopedic appliances[6-8]. Others[9,10] are however unable to show the effects of treatment on condylar cartilage and explain the facial changes accompanying these therapies as being mainly dentoalveolar compensations.

In vitro animal[11-13], and human fetal[14] studies have shown little intrinsic growth potential of secondary condylar cartilage in comparison to primary cartilage from epiphyseal plates. Petrovic and Stutzmann[5] have argued that the functional environment and action of the lateral pterygoid muscle are important in development of condylar cartilage and hence the mandible. Independently, this lead Copray et al[15] to conclude that local environmental factors are of importance in considering condylar growth.

Internal derangement of the temporomandibular joint (TMJ) has been defined by

Dolwick[16] as the "abnormal relationship of the articular disc to the condyle, fossa and articular eminence, with the disc usually displaced in an anteromedial direction". Since disc displacement can be seen as a loss of harmony between functional TMJ components, disc displacement may be considered a local environmental disturbance with potential to affect condylar development.

Juvenile Rheumatoid Arthritis has been shown to have a profound effect on craniofacial growth, presumably by inflammatory destruction of the condylar cartilage[17-19]. Altered condylar morphology or loss of normal shape, as seen on plain film radiography, has been associated with altered craniofacial morphology, although no clear cause and effect mechanism was postulated[20]. Patients with disc displacement without reduction show osseous changes of the condylar head, but these changes are less frequently found in patients with disc displacement with reduction[21-22]. A strong relationship between disc perforation and degenerative joint disease of the temporomandibular joints has been shown, whereas the relationship between internal derangement and degenerative joint disease is less evident[23].

Internal derangement represents a less "violent" change in the local environment. Nevertheless, disc displacement "pulls" the retrodiscal tissue forward between the condyle and articular eminence with potentially harmful effects. Compression of this normally vascular tissue may occur, altering oxygenation, nutrition, and lubrication of condylar tissue through synovial fluid changes. These localized changes may be adequate to alter the dynamic growth within this region resulting in a loss of facial growth equilibrium expressed in the various adaptive growth sites. The aim of this study was to determine whether temporomandibular disc displacement is associated with specific craniofacial characteristics.

## 2.2 Subjects and Methods

A pilot study was conducted on individuals drawn from an orthodontic practice prior to appliance placement. Thirty two individuals volunteered inclusion, seven were excluded due to poor MRI or cephalometric quality. The sample included both male and females, with an age range of 10-17 years, and a mean age of 12.8 years (Table 2.1). The group consisted of individuals with and without clinically detectable TMJ symptomology (capsular pain; joint sounds; masticatory muscle tenderness; limited mandibular range of motion; deviation on opening)

| | **Males** | **Females** |
|---|---|---|
| **Total Number** | 5 | 20 |
| **Mean Age (years)** | 12.6 | 12.9 |
| **Age Range (years)** | 11 -15 | 10 -17 |

Table 2.1: Study Population

Closed mouth lateral cephalometric radiographs were obtained making use of a polyvinylsiloxane (President Jet-Bite, Coltene/Whaledent Inc. Mahwah, NJ) centric occlusion bite registration. Open mouth, lateral cephalometric radiographs were exposed to accurately determine the shape of the head of the condyle. A left hand wrist radiograph was produced to determine skeletal age of the individual, making use of Greulich and Pyle's skeletal maturity indicators[24]. All radiographs were acquired making use of a Siemens OP10 radiographic machine.

Lateral cephalometric radiographs were traced on acetate tracing film by a single investigator (BN). An accurate outline of the condylar head was obtained by superimposing the closed mouth tracing of the symphysis, the lower border of mandible, developing dental follicles and enamel organ where present, on the open mouth image.

Cephalometric landmarks utilized are illustrated in Fig. 2.1, and defined in Table 2.2. Cephalomeric measurements, angles and ratios are presented in Table 2.3 - 2.5. Linear measurements were made with a Mitutoyo digital caliper accurate to 0.01 mm (Mitutoyo Canada Inc. Mississauga, Ontario, CA), angular measurements were determined making use of a protractor accurate to 1 degree. Each subject was age and sex matched to population norms presented in the Craniofacial Growth Series[25]. Maxillary unit lengths (Co-ANS") were not matched to the Craniofacial Growth Series data, but to data presented by McNamara[26].

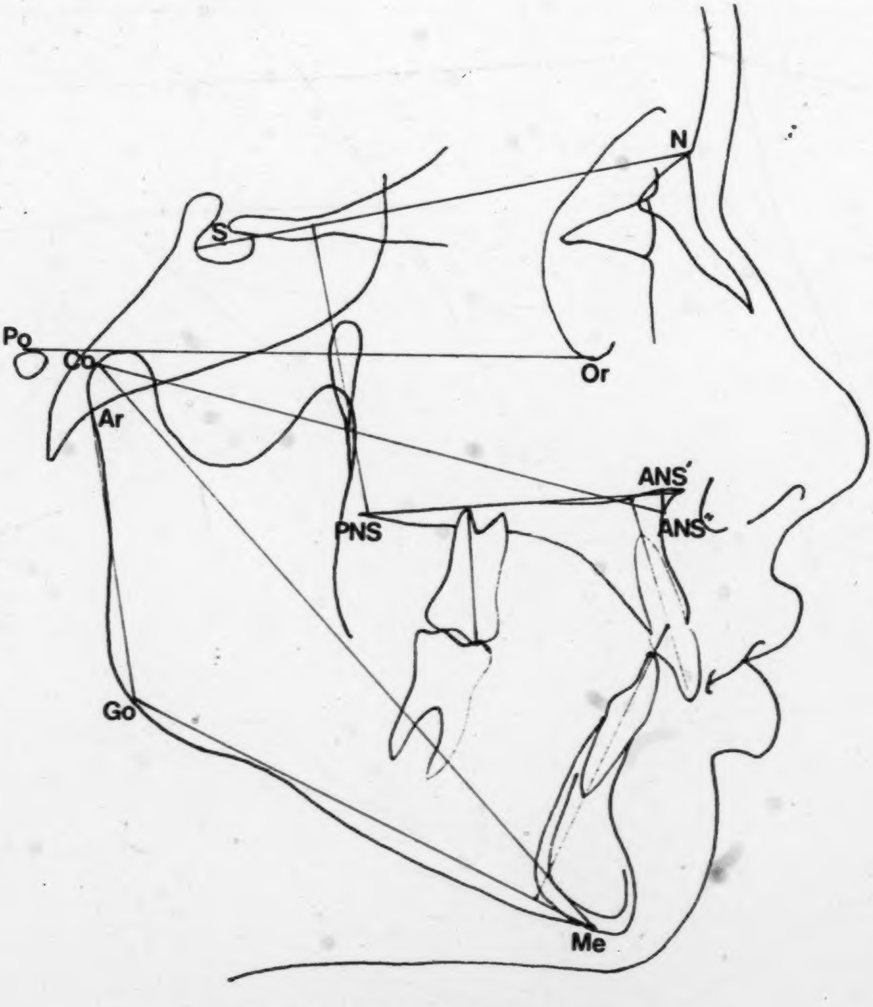

Figure 2.1 : Cephalometric Landmarks and Planes

| Abbreviation | Definition of landmarks and planes |
|---|---|
| S | Sella - Center of pituitary fossa of sphenoid bone as identified by visual inspection |
| N | Nasion - Junction of frontonasal suture at most posterior point on curve at the bridge of the nose |
| ANS | Anterior nasal spine - Tip of median bony process of the maxilla at lower margin of anterior nasal opening |
| ANS' | A point on upper contour of ANS where vertical thickness is 3 mm |
| ANS" | A point on lower contour of ANS spine where vertical thickness is 3 mm |
| PNS | Posterior nasal spine - most posterior projection of bony contour of palate |
| Co | Condylion - most postero-superior point on bony outline of the average right and left condylar head |
| Go | Gonion - most postero-inferior point on bony angle of average left and right mandibular outlines |
| Me | Menton - most inferior point on bony outline of mandibular symphysis in midsagittal plane |
| Ar | Articulare - intersection of inferior cranial base surface and the averaged posterior surfaces of the mandibular condyles |
| ANS - PNS | Palatal plane - plane formed by connecting ANS point and PNS point |
| SN | Sella-nasion - plane formed by connecting S and N points |
| OP | Functional occlusal plane - A plane drawn through points of contact between the first permanent molar and first and second premolars (or of deciduous molars) |
| Go - Me | Mandibular plane - plane formed by connecting Go and Me points |

Table 2.2: Cephalometric Landmarks and Planes

| **Cephalometric landmarks** | **Linear measurements** |
|---|---|
| N-ANS' | Anterior upper facial height (AUFH) |
| ANS'-Me | Anterior lower facial height (ALFH) |
| N-Me | Anterior total facial height (ATFH) |
| Co-Go | Ramus height (RH) |
| OP-(ANS - PNS) | Perpendicular distance from mesiobuccal cusp tip of maxillary first molar to palatal plane (6-PP) |
| Go- Me | Mandibular corpus length (CL) |
| Co-ANS" | Anteroposterior maxillary length (Max) |
| Co-Me | Anteroposterior mandibular length (Mnd) |
| S-Go | Total posterior face height (TPFH) |
| (ANS - PNS) - SN (perp to SN) | A perpendicular from SN to PNS at point of intersection with inferior of pterygomaxillary fissure (PUFH) |

Table 2.3: Linear Cephalometric Measurements

| **Cephalometric landmarks** | **Angular measurements** |
|---|---|
| SN/Go-Me | Mandibular plane angle (MP) |
| Ar-Go-Me | Gonial angle (AGM) |
| SN/PNS-ANS | Palatal plane angle (SN-PP) |
| Interincisal angle | Interincisal angle (INC) |

Table 2.4: Angular Cephalometric Measurements

| Cephalometric landmarks | Ratio |
|---|---|
| S-Go : N-Me | Posterior facial height to anterior facial height (TPFH:ATFH) |
| N-ANS' : ANS'-Me | Anterior upper facial height to anterior lower facial height (AUFH:ALFH) |
| ANS'-Me : N-Me | Anterior lower facial height to anterior total facial height (ALFH:ATFH) |

Table 2.5: Ratios of Linear Cephalometric Measurements

Magnetic Resonance Imaging (MRI) of the TMJs were performed on the same day as the radiographic evaluation. MRI was completed without sedation using a 1.0 T magnet (Shimadzu Corporation 3, Tokyo, Japan) and a unilateral 3 inch surface receiver coil. Axial scout images were obtained to identify the condyles. Bilateral closed-mouth parasagittal sections were obtained making use of the same bite registration employed for closed mouth lateral cephalometric radiography. Bilateral open mouth parasagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening. T1-weighted 500/20 (TR ms/ TE ms) pulse sequences were performed on all subjects using a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204. A single radiologist with expertise in interpretation of TMJ MR images traced the articular structures and the posterior band of the articular disc on all parasagittal MRIs.

Disc position was evaluated in accordance with the principles of Drace and Enzmann[27]. The disc was considered to be in a normal relation to the articular structures, in the closed mouth position, when the posterior band (junction of the posterior band and bilaminar zone) of the disc was within plus or minus 10 degrees of the 12 o'clock position of the head of the condyle. Disc displacement was measured as the anterior or posterior angular deflection of the posterior band of the disc from the 12 o'clock position (Fig. 2.2). The influence of the orientation of the posterior slope of the eminence had on disc position could not be considered using this technique.

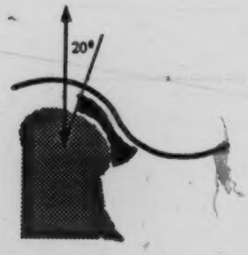

Figure 2.2: Determination of Disc Position (Drace & Enzmann 1990)

### 2.3 Statistical Evaluation

Ten radiographs were randomly selected and traced on five separate days by the same investigator, (BN), to determine reproducibility of landmark identification and measurement technique. A One-way random effects model, with radiographs as factors and tracings as nested effects within the factors, was used to consider the intraclass correlation coefficient. Based on this model the independent cephalometric variables were tested making use of a univariate F-test. Variability between tracings within patients was insignificant for all variables ($p > 0.04$) except for Co-Go, S-Go, and SN/Go-Me ($p < 0.01$). Standard Error of the Mean (S.E.M.) for each variable was computed making use of the within patient variability in tracing, ignoring the between patient variability of each independant variable to determine the angular or linear measurement error for each cephalometric variable measured (Table 2.6).

For each patient 10 linear, 4 angular and 3 ratio measurements were compared to an age and sex matched "standard population" from the Craniofacial Growth Series[25]. A stepwise multiple regression analysis was utilized to determine the relationship between angular disc displacement and cephalometric variables.

Independent variables were obtained from the lateral cephalometric radiographs, and were defined as: (Equation 1.) The cephalometric variable for the subjects ($CV^{S}$) minus the mean of the cephalometric variable for the "standard population" ($CV^{STD}$), divided by the standard deviation of the cephalometric variable for the "standard population" ($SD^{STD}$). This generated a Standardized score which was used as the independent variable.

$$\frac{CV^{S} - CV^{STD}}{SD^{STD}} = \text{Standardized score}$$

**Equation 2.1:** Production of a Standardized score

| Independent Variables | S.E. Mean * |
|---|---|
| ANS'-Me | 0.409988 |
| OP-(ANS - PNS) | 0.430488 |
| SN/Go-Me | 0.517204 |
| (ANS - PNS) - SN | 0.517793 |
| S-Go | 0.551435 |
| Ar-Go-Me | 0.578792 |
| N-ANS' | 0.597244 |
| N-Me | 0.600941 |
| SN/PNS-ANS | 0.602080 |
| Co-Me | 0.603573 |
| Interincisal angle | 0.817007 |
| Co-ANS" | 0.898838 |
| Co-Go | 0.921450 |

*Degrees of Freedom associated with S.E.M. values are 40

Table 2.6: Reproducibility of Landmark Identification

Sine transformation of the angular displacement of the posterior band of the disc from the 12 o'clock position, obtained from MRI interpretation, was used as the dependent variable. Analyses were computed making use of an S-Plus statistical package. The difference in magnification factors in radiographs of the current study and that obtained in the Craniofacial Growth Series was not factored into the analyses as this was calculated to be only 1.08%.

## 2.4 Results

The angular displacement of the posterior band of the articular disc from the 12 o'clock position in the L TMJ had a mean of $22.84^0$ (SD 29.15; range $-13^0$ to $95^0$), the mean disc displacement in the R TMJ was $28.94^0$ (SD 29.78; range $-10^0$ to $91^0$). Results of a stepwise multiple regression analysis are provided in Tables 2.7 and 2.8 together with p-values and regression coefficients. Variables with p-values $< 0.05$ were not deleted from the model, as this would have resulted in a significant loss of information in predicting the responses (L TMJ/R TMJ). Stepwise multiple regression analysis showed a positive association between angular transformation measurements of disc displacement and maxillary length; mandibular plane; SN to palatal plane, and a negative association between disc displacement and vertical ramus height; posterior facial height; posterior to anterior facial height ratio; and upper molar height to palatal plane. R-square values for seven variables for left TMJ was .91 and for right TMJ was .82. Differences in regression coefficients and R-squared values between left and right TMJs was possibly due to the asymmetrical nature of disc displacement evidenced on MRIs of the TMJs.

| Independent Variable | Dependent Variable L TMJ | Regression Coefficient L TMJ |
|---|---|---|
| **Co - ANS"** | positive association (p=0.03 ) | 0.081576 |
| **S-N / Go - Me** | positive association (p=0.02 ) | 0.239062 |
| **SN - (ANS - PNS)** | positive association (p=0.0003 ) | 1.37304 |
| **TPFH: ATFH ratio** | negative association (p=0.0002 ) | -1.3978 |
| **OP - (ANS - PNS)** | negative association (p=0.043 ) | -0.09234 |
| **Co - Go** | negative association (p=0.0001 ) | -0.142356 |
| **S - Go** | negative association (p=0.003 ) | -0.9873 |
| **$R^2$ value** | .91 | |

Table 2.7: Results of Multiple Regression Analysis for L TMJ Based on 25 Subjects

| Independent Variable | Dependent Variable R TMJ | Regression Coefficient R TMJ |
|---|---|---|
| **Co - ANS"** | positive association (p=0.002 ) | 0.286513 |
| **S-N / Go - Me** | positive association (p=0.009 ) | 0.433316 |
| **SN - (ANS - PNS)** | positive association (p=0.0018 ) | 0.78345 |
| **TPFH: ATFH ratio** | negative association (p=0.0013 ) | -0.912035 |
| **OP - (ANS - PNS)** | negative association (p=0.0012 ) | -0.978231 |
| **Co - Go** | negative association (p=0.0015 ) | -0.822341 |
| **S - Go** | negative association (p=0.0001 ) | -1.34567 |
| **$R^2$ value** | .82 | |

Table 2.8: Results of Multiple Regression Analysis for R TMJ Based on 25 Subjects

## 2.5 Discussion

In treatment planning of adolescent individuals, the orthodontist is aware that facial growth may be altered by manipulation of three adaptive growth sites, the maxillary sutural system, the dentoalveolus and the condyle of the mandible. Orthopedic and orthodontic forces have been applied to the maxillary sutural system and the dentoalveolus with great success, but manipulation of condylar cartilage growth has been less predictable. This has possibly resulted in practitioners shying away from treatment involving the mandibular condyle as an important adaptive growth site with potential of influencing craniofacial morphology.

In the adult population the pathogenesis of degenerative joint disease has been linked to internal derangement[22,28]. Facial patterns accompanying internal derangement in the adult patient were noted by Link and Nickerson[29] in an adult surgical sample. Bjork[30] presented the gross morphological alterations that may be expected in the craniofacial region when there is a total lack of condylar cartilage growth contributing to mandibular development and facial growth in the growing individual. These articles serve to illustrate identified associations between altered craniofacial morphology and localized TMJ disturbances.

Stegenga et al[31] have argued that internal derangement alters the physical properties of the TMJ and affects its ability to withstand compressive and shearing forces. Increased friction between the articular surfaces may impair joint movement and may elicit pathologic responses of the cartilage and adjacent tissues, such as subchondral bone and associated musculature. This being the case the adaptive growth response of condylar cartilage may be affected. An alteration in TMJ and related muscle function may further inhibit condylar development. Growth alterations may be detected in the developing craniofacial structures, and in particular the mandible of the adolescent individual.

The findings of the current study tend to support the argument that internal derangement may be associated with an altered craniofacial morphology in an adolescent sample. This pilot study shows a reduction in total posterior facial height development, a reduction in ramus height, and a compensatory adaptation in the maxillary dentoalveolar region with reduced vertical development of the maxillary first molar region. These craniofacial alterations occur in the presence of internal derangement in the L TMJ and/or R TMJ. In association with a lack of posterior facial height development, a compensatory clockwise rotation of the palatal plane and the mandibular plane relative to sella-nasion was recorded. From this pilot study it appears that maxillary growth was expressed in a more anterior direction due to limitations imposed on its vertical development by the relatively mature cranial base posterosuperiorly, and reduced vertical mandibular growth postero-inferiorly.

The reader should be cautioned in that these are preliminary results, obtained from a small sample. The explained variance presented in Table 2.6 is possibly higher than expected due to the small sample size relative to the number of independent variables analyzed. A more complete study with a larger sample and a control sample is necessary to evaluate TMJ internal derangement in the adolescent population. Furthermore, this study represented a cross-sectional evaluation, and at present no longitudinal data involving MRI assessment of disc position are available to support the concept of growth alteration that may be occurring. This should in no way diminish our responsibility to identify internal derangements in the adolescent population and to further our understanding of the sequelae of the disorder.

## 2.6 Conclusions

The results of the pilot study indicate that internal derangement in the adolescent population may be associated with certain craniofacial features:

Reduced ramus and total posterior facial height compared to the norms.

Dentoalveolar adaptation in the posterior maxillary region, with reduced upper molar to palatal plane height.

Increase palatal plane angle, and mandibular plane angles relative to sella-nasion.

Increased degree of disc displacement has a positive association with increased maxillary anteroposterior dimension.

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# CHAPTER 3

## Magnetic Resonance Imaging of Temporomandibular Joint: Interobserver Agreement in Subjective Classification of Disc Status

### 3.1 Introduction

Magnetic resonance imaging (MRI) has gained wide acceptance in the evaluation of the temporomandibular joint (TMJ) and shows high diagnostic accuracy in the determination of osseous pathology and articular disc position[1-5].

The current standard for interpretation of TMJ images relies on subjective evaluation, and is dependent on examiner experience and familiarity with TMJ morphology, function and pathophysiology. Subjective evaluation of MRI determined TMJ disc position makes comprehensive use of all diagnostic images obtained in the scanning protocol, including both coronal and sagittal images, which provide information regarding disc position throughout the joint[6-8]. This information is important in determining degree and direction of disc displacement. Unfortunately there is no standardization of terminology, nor is there an adequate indication of the degree of the disorder. An understanding of what constitutes a mild disc displacement to one observer may not be in agreement with that of a second observer. More importantly, clinical management may hinge on the choice of terms used by the observer, and the use of misleading terminology makes it difficult to establish the prevalence and incidence of a disorder in the population.

Regardless of the difficulties in subjective evaluation, acceptable interobserver agreement in the interpretation of MR images of disc position in the TMJ have been reported[5,9]. In these studies strict guidelines and standardized criteria for classification of TMJ disc position on MR images increased the level of agreement between observers and reduced the ambiguity of subjective evaluations. Standardization of viewing facilities further reduced the interobserver variability in interpretation of these images, but most importantly, these observers trained and worked together for a significant period of time[9]. Observers with different backgrounds and training are not expected to be as consistent in interpretation as similarly trained individuals[10].

Individual anatomical differences within subjects being imaged is yet another source of variability in image production. The presence of inflammation within the temporomandibular joint has the effect of altering the signal from the associated tissues[11], while varying degrees of disc displacement and loss of discal morphology may influence the precision of joint structure identification[12,13]. The age of the subject may also influence the image generated. Mature individuals are able to maintain a static position for extended periods of time and are generally more responsive to examiner requests than adolescents. Slight movements produce motion artifacts on the images produced, increasing the challenge of interpretation.

An appreciation of those factors that influence image quality is essential in the interpretation of MR images. Similarly the importance of precise subjective interpretation of these images should not be understated. Consistent interpretation of MR images is of great interest to the clinician and researcher so that clinical or statistical significance may be assigned to these findings.

Interobserver variability between two observers in the interpretation of MRI's of the TMJ has been reported in the literature[5,9]. Information on interpretation of images by more than two observers with varied backgrounds and training is, however, not available. This study aims to examine interobserver agreement in interpretation of MRIs of the TMJ by four independent observers. All observers have expertise in MRI interpretation of the TMJ, but have not previously worked together. Furthermore, interobserver agreement within the assigned categories is of particular interest for determining which categories of disc position show most variability in observer interpretation.

### 3.2 Methods and Materials

Magnetic Resonance Imaging was performed on the TMJs of 194 consenting adolescent subjects (male and female) between the ages of 10 and 17 years. This imaging study was approved by the Joint Dentistry/ Pharmacy Human Ethics Committee. All images were acquired without sedation using a 1.0 T magnet (Shimadzu Corporation, Tokyo, Japan) and a unilateral 3 inch surface receiver coil. Axial scout images were obtained to identify the condyles. Bilateral closed-mouth sagittal sections were obtained making use of a polyvinylsiloxane centric occlusion bite registration (President Jet-Bite, Coltene/ Whaledent Inc. Mahwah, NJ). Bilateral open-mouth sagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening. All sagittal images were obtained perpendicular to the condylar long axis as determined by axial scout imaging. Coronal images were acquired parallel to the long axis of the head of the mandibular condyles. T1-weighted 500/20 (TR ms/ TE ms) pulse sequences were performed on all subjects using a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204.

A random sample of seventy right or left MR images was selected from the adolescent study group. MR images of ten joints were used for initial calibration by each observer, and the remaining sixty joints were used for interobserver reliability testing. All joints had a set of images which consisted of the following:

- an axial localizing scan,
- a sequence of four coronal closed-mouth images parallel to the condylar long axis,
- a sequence of four to six sagittal closed-mouth images perpendicular to the condylar long axis, and

- a sequence of four sagittal open-mouth images perpendicular to the condylar long axis.

Each set of images was independently interpreted by four observers: three maxillofacial-dental radiologists experienced in interpretation of MRI of the TMJ and an orthodontist, the principal investigator, who was included as an observer after an extensive training period which included the theory of MR imaging and evaluation of MRIs of the TMJ. All observers were blind as to clinical signs and symptoms of subjects imaged. Prior to interpretation of the images, each observer received a set of written guidelines and classification criteria for disc position. Observers were requested to evaluate articular disc status according to the established classification guidelines. No classification of osseous structures was attempted. Classification of disc position was made according to six categories (Figure 3.1):

1. *Normal disc position*

   The intermediate zone of the articular disc was interposed between the head of the condyle and the posterior slope of the articular eminence[14]. The anterior and posterior bands are equally spaced on either side of the intermediate zone of the disc.

2. *Slight anterior displacement of the disc*

   The posterior band of the disc was found in contact with the condyle. The intermediate zone of the disc was slightly anteriorly displaced from between the osseous articular components.

3. *Moderate anterior displacement of the disc*

   The condyle was in contact with the junction between the posterior band of the disc and the bilaminar zone. The intermediate zone of the disc was completely displaced from between the osseous articular structures.

4. *Full displacement of the articular disc*

   The bilaminar zone of the disc was interposed between the osseous articular structures. The entire articular disc was anteriorly displaced and had lost contact with the loaded osseous articular surfaces. The intermediate zone of the disc however assumed a normal interarticular position on mouth opening.

(Categories 1-4 all exhibited disc reduction on mouth opening)

5. *Full displacement of the articular disc without reduction on opening*

   As for 4, but without reduction of the disc on mouth opening.

6. *Non-categorizable disc position*

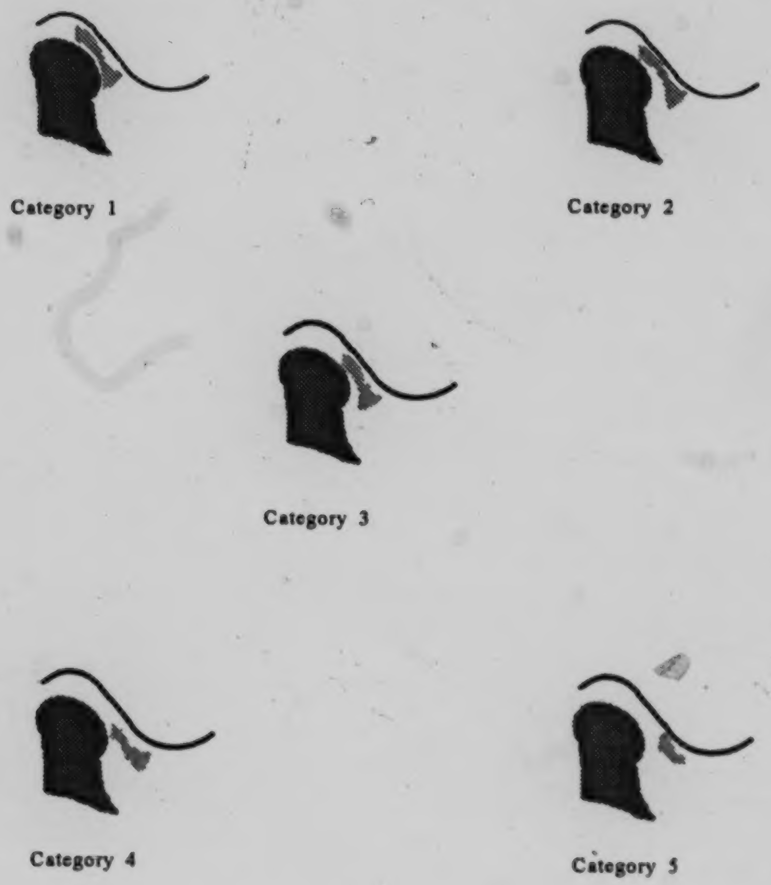
   Disc position could not be determined due to poor diagnostic quality of MR images.

From the subjective evaluation a categorical score of 1 - 6 was assigned to both the medial and lateral sagittal slices of each joint, according to the set criteria. Each observer generated 120 categorical scores for the sixty joints interpreted, with a total of 480 categorical scores for all the observers. Interobserver variablility was measured for the medial and lateral aspects of the joints using Kappa statistics (6).

### 3.3 Data Analysis

Kappa statistics (6), their standard error (SE), Z - statistic (6/SE), and 95% confidence intervals (95% C.I.) were computed for simultaneous agreement amongst the four observers making use of a Fortran program[15] based on an algorithm by Fleiss[16]. The same statistics were also generated for each individual category of disc position[16]. Kappa statistics are commonly interpreted as: <0.00 - poor agreement, 0.00 - 0.20 - slight agreement, 0.21 - 0.40 - fair agreement, 0.41 - 0.60 - moderate agreement, 0.61 - 0.80 - substantial agreement, and 0.81 - 1.00 - almost perfect agreement. These divisions are arbitrary, but do provide useful "benchmarks" for the interpretation of the findings[17].

Since one of the observers was an orthodontist and not a maxillofacial dental radiologist, the effect of this observer on image interpretation was determined by sequentially removing a single observer's scores from the analysis. In this way kappa statistics were computed for combinations of any three observers and the effect of the orthodontist on interpretation of images could be determined.



Category 1

Category 2

Category 3

Category 4

Category 5

Figure 3.1: Categories of Disc Status

### 3.4 Results

Kappa statistics, standard error, Z-statistics, and 95% confidence intervals for all four observers are presented in Table 3.1 for the medial and lateral components of the joints. The 95% C.I. for interobserver kappa statistic in assessment of the medial aspect of the

TMJ's was between 0.486 - 0.622, illustrating moderate to substantial agreement amongst all observers. Interobserver 95% C.I. of kappa statistic for the lateral aspect of the joints varied slightly less, from 0.450 - 0.566, but showed only moderate agreement amongst all observers.

Kappa statistics were computed for the medial and lateral components of the joints for all combinations of three observers, each time excluding one of the observers. The relevant kappa statistic, standard error, and Z - statistic are included in Table 3.2 for the medial and lateral components of the joint. Exclusion of observer 4, the orthodontist, produced the lowest kappa statistic values for both the lateral and medial components of the joint. This means that when observer 4 is excluded the agreement amongst observers decreases, and when included agreement amongst observers improves, as indicated by the kappa statistic score. Observer 4 had the benefit of discussing classification procedures with each of the maxillofacial dental radiologists before independently scoring the TMJ images, which may have improved the agreement between observer 4 and the other observers.

| **Joint Component** | **Kappa statistic** | **S.E. of Kappa** | **Z statistic** | **95% C.I.** |
|---|---|---|---|---|
| **Medial** | 0.554 | 0.034 | 16.0 | 0.486 - 0.622 |
| **Lateral** | 0.508 | 0.029 | 17.6 | 0.450 - 0.566 |

Table 3.1 : Kappa Statistics for Interobserver Agreement Amongst All Four Observers

Interobserver agreement amongst all four observers for each category was computed for both the medial and lateral aspects of the joints. Table 3.3 contains the kappa statistic, standard error, and Z - statistic for each category for the medial and lateral aspects of the joints. Interpretation of kappa statistics show almost perfect agreement (6 = 0.914) amongst all observers in assessing total disc displacement without reduction in both the lateral and the medial aspects of the joint. Substantial agreement occurred amongst all observers in categorizing total disc displacement with reduction in the lateral aspect of the joint (6 = 0.652). Agreement in interpretation of total displacement with reduction in the medial aspect of the joint was, however only moderate (6 = 0.407). Interobserver agreement in interpretation of normal disc position was substantial (6 = 0.665) in the medial aspect of the joint and moderate (6 = 0.498) in the lateral aspect. Agreement amongst observers for categorization of disc position in either lateral or medial aspect of the joint was only slight to fair for disc displacement categorized as slight or moderate displacement. Non-categorizable disc position had only fair agreement amongst observers.

| Joint Component | Observer Excluded | Kappa statistic | S.E. of Kappa | Z statistic |
|---|---|---|---|---|
| **Medial** | 1 | 0.613 | 0.0407 | 12.948 |
| | 2 | 0.556 | 0.043 | 13.042 |
| | 3 | 0.538 | 0.044 | 12.348 |
| | 4 | 0.508 | 0.044 | 11.548 |
| **Lateral** | 1 | 0.515 | 0.042 | 12.195 |
| | 2 | 0.494 | 0.037 | 13.454 |
| | 3 | 0.561 | 0.039 | 14.564 |
| | 4 | 0.457 | 0.041 | 11.147 |

Table 3.2 : Interobserver Agreement Amongst Any Three Observers

| Joint Component | Category | Kappa statistic | S.E. of Kappa | Z statistic |
|---|---|---|---|---|
| **Medial** | 1 | 0.665 | 0.154 | 4.312 |
| | 2 | 0.189 | 0.124 | 1.521 |
| | 3 | 0.301 | 0.125 | 2.414 |
| | 4 | 0.407 | 0.108 | 3.780 |
| | 5 | 0.914 | 0.128 | 7.127 |
| | 6 | 0.377 | 0.136 | 2.776 |
| **Lateral** | 1 | 0.498 | 0.143 | 3.469 |
| | 2 | 0.148 | 0.125 | 1.182 |
| | 3 | 0.273 | 0.124 | 2.196 |
| | 4 | 0.652 | 0.125 | 5.224 |
| | 5 | 0.914 | 0.128 | 7.127 |
| | 6 | 0.377 | 0.136 | 2.776 |

Table 3.3 : Interobserver Agreement by Category for Medial and Lateral Aspects of Joints

## 3.5 Discussion

This study confirms that in the interpretation of MR images of the TMJ, moderate to substantial observer agreement can be achieved amongst experienced observers applying standardized classification criteria. Variability between observers occurred mostly in the intermediate stages of disc displacement as defined by the classification criteria.

The greatest interobserver agreement was achieved in category five, followed by category one and four. This indicates that observers agree in identification of totally displaced discs without reduction, while interobserver agreement was moderate to substantial for categorization of discs as normal or total disc displacement with reduction. Individual observers are therefore confident in identification of normal disc position and discs that are displaced with and without reduction on open-mouth images.

Observer agreement was, however, weak when other categories of disc position were considered, indicating only slight agreement amongst observers in defining joints with slight disc displacement, and fair agreement in identifying moderate disc displacement. These categories of disc position are arguably difficult to determine and assign. Observers are not accustomed to differentiating between slight and moderate disc displacement and no guidelines have previously been determined to distinguish between these categories. Slight and moderate disc displacement cannot, however, be viewed as either normal disc position or as a total disc displacement. It is encouraging to note that moderate disc displacement had fair interobserver agreement, indicating that this category may be identified as being distinct in the continuum of disc positions identified. The clinical and functional significance of moderate disc displacement, and its progression to total disc displacement, however, needs further investigation.

In this study there seems to be a trend for the observers to have a greater degree of agreement in interpretation of disc position in the medial aspect of the joint compared to interpretation of disc position in the lateral aspect of the joint. This is in agreement with previously published findings which indicate that in lateral aspects of the joint, disc displacement is less clearly identified than in the medial aspect of the joint[4]. The cause of inconsistent interpretation in the lateral aspect of the joint has been blamed on the higher prevalence of slight disc displacement occurring in small regions of the lateral aspect of the joint.

Overall observer variability is likely to be greater when observers from different institutes and different training backgrounds are compared[10]. Agreement amongst observers is expected to be reduced if individuals have varied training backgrounds, and have not interacted with one another to gain consensus on interpretation of MR images. This is likely to represent the discrepancies encountered in the day-to-day clinical setting. It is important to note that as the number of observers interpreting images increases, the interobserver agreement reduces to less than that expected for any pair of observers interpreting the images. Unfortunately this has not been demonstrated in the literature pertaining to MRI interpretation of TMJ images, as most studies make use of only two observers to determine interobserver variability. Interobserver variability in interpretation of MR images of other body parts by more than two observers do, however, illustrate the reduction in interobserver agreement as the number of observers are increased[18,19].

## 3.6 Conclusion

This study shows that in the interpretation of randomly drawn MR images of the TMJ, moderate to substantial observer agreement across all defined categories can be achieved amongst a number of experienced observers using standardized classification criteria.

Interobserver agreement is, however, shown not to be uniform across all categories of disc position described. Observers show greatest agreement in classifying joints considered to have total disc displacement without reduction, followed by moderate to substantial agreement in categorizing total disc displacement with reduction and normal disc position. Weaker agreement occurred amongst observers in categorization of slight and moderate disc displacement, as well as in assignment of joints to the non-categorizable group.

Furthermore, this study indicated a trend toward greater interobserver agreement in categorization of disc position in the medial aspect of the joint compared to the lateral aspect. This was consistent for all categories other than category four, where interobserver agreement was greater for the lateral aspect of the joint, and for categories five and six where interobserver agreement was the same for both medial and lateral aspects of the joint.

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# CHAPTER 4

## Quantitative Assessment of the Temporomandibular Joint Disc Status.

### 4.1 Introduction

Magnetic resonance imaging (MRI) has been utilized to obtain information regarding articular disc position within the temporomandibular joint (TMJ) in individuals[1] and autopsy specimens[2-4]. It provides a direct form of soft tissue visualization with excellent spatial and contrast resolution on sagittal and coronal MR images of the TMJ[3,5,6]. It also offers the advantage of being noninvasive, pain free, of minimal risk potential, and free of ionizing radiation exposure[7]. In contrast to indirect imaging with arthrography, MRI produces no soft tissue distortion due to injection of contrast medium into the joint space[7]. In addition, MRI has been shown to have high sensitivity and specificity for identification of condyle disc relationships[2,8-11].

The interpretation of TMJ images relies on the subjective evaluation and is dependent on examiner experience[11]. A subjective assessment of images may be adequate for clinical purposes, however a quantitative evaluation method would provide more rigorous data which may aid in understanding the mechanisms involved in disease or disorder processes.

To identify a disorder, it is necessary to characterize what is "the range of normal". In the TMJ the articular disc has been described as normally positioned relative to the osseous articular structures when the following imaging criteria are met:

1. At maximal intercuspation, the posterior band of the disc is located at the twelve o'clock position, and
2. the intermediate zone of the disc is interposed between the head of the condyle and the posterior slope of the articular eminence[6,12].

The definition of normal disc position as defined and used by Katzberg *et al*[13], Drace and Enzmann[14], and others[6,15,16], may be anatomically correct, but it is spatially deficient. Standardization of the twelve o'clock position relative to the TMJ is difficult due to variation in head position during imaging. As a result, the interpretation of the most superior outline of the glenoid fossa and condyle may have significant error, and may be influenced by the depth of the fossa, the slope of the articular eminence, inclination of the head of the condyle, as well as the inclination of the ascending ramus of the mandible. Thus quantification of disc status making use of the twelve o'clock position may over- or under-estimate the severity of disc displacement. Functional orientation of the disc in the normal position may serve as a more meaningful basis for evaluation[17,18].

Disc displacement or internal derangement is an alteration of this functional relationship of the disc to the articular structures. Although imaging provides only two-dimensional visualization, disc position can be described in three planes of space. The displaced articular disc may be described according to the degree and direction of disc displacement.

Quantification of TMJ disc position has been attempted making use of both arthrography[17] and MRI[14,19,20]. Heffez[17] determined the position of the intermediate zone of the disc in relation to osseous articular structures on arthrography. The posterior slope of the articular eminence and a constructed centroid point of the condyle served as osseous references. While this functional analysis is useful, the defined condyle centroid point may not be functionally related to the articular components of the joint. Arthrography also cannot differentiate the exact intermediate zone of the disc once disc displacement and deformation has occurred.

Subjective evaluation of MRI determined TMJ disc position makes comprehensive use of all diagnostic images obtained in the scanning protocol. Coronal images, parallel to the long axis of the condyle are of value in determining lateral or medial sideways rotations and displacements[5,6]. Parasagittally corrected images from the medial to lateral component of the joint provides a continuum of information regarding disc position throughout the joint. This information is important in determining degree and direction of disc displacement. Selection of a single diagnostic slice which best depicts joint structures should be avoided if loss of information is to be safe-guarded[19]. Also, investigator bias may be introduced if a single slice is selected from a continuum. Despite subjective assessment of disc position on multiple MR images being comprehensive, quantification of this method has not been possible.

A reliable method of quantification of TMJ disc slice information as produced by MRI is therefore necessary to enhance our understanding of TMJ disorders. The purpose of this study was to quantify TMJ disc slice information as produced by multiple sagittal MRI. The degree of disc displacement, disc length, and the ratio of these measurements were used as variables in a discriminant analysis, to determine the status of the articular disc.

## 4.2 Methods And Materials

Information was gathered on 194 subjects (75 males and 119 females) between the ages of 10 and 17 years, regardless of TMJ disc position, without previous or current orthodontic therapy. All individuals consented to inclusion in the study which was approved by the Joint Dentistry/ Pharmacy Human Ethics Committee. Individuals were recruited from the graduate orthodontic program at the University of Alberta and from private orthodontic practices in the area, prior to undergoing orthodontic treatment. The group consisted of subjects with and without clinically detectable TMJ signs and symptoms (capsular pain; joint sounds; masticatory muscle tenderness; limited mandibular range of motion; deviation on opening).

Magnetic Resonance Imaging (MRI) of the TMJs were performed without sedation using a 1.0 T magnet (Shimadzu Corporation 3, Tokyo, Japan) and a unilateral 3 inch surface receiver coil. Axial scout images were obtained to identify the condyles. Bilateral closed-mouth sagittal sections were obtained perpendicular to the long axis of the condyle, and coronal images were obtained parallel to the condylar long axis. Closed mouth images were obtained making use of polyvinylsiloxane (President Jet-Bite, Coltene / Whaledent Inc. Mahwah, NJ, USA) centric occlusion bite registration. To prevent muscle fatique, bilateral open mouth sagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening. Subjects were instructed to rest the anterior teeth on the blades of the caliper. T1-weighted 500/20 (TR ms/ TE ms) pulse sequences were performed on all subjects using a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204.

All joints were subjectively evaluated by an experienced maxillofacial radiologist to determine disc position from the coronal, as well as sagittal MRI slices. Of the 194 subjects imaged (388 joints), only thirty-five joints were excluded due to poor MRI quality, possibly as a result of motion artifacts. Six categories of disc position were identified, with categories 1 to 4 all exhibiting disc reduction on mouth opening:

1. *Normal disc position*

   In the closed mouth position the intermediate zone of the disc was interposed between the head of the condyle and the posterior slope of the articular eminence, with the anterior and posterior bands equally spaced on either side of the condylar load point in a bow tie appearance[21].

2. *Slight anterior displacement*

   The intermediate zone of the disc was slightly anteriorly displaced from between the osseous articular components. The head of the condyle apposed the posterior band of disc.

3. *Moderate anterior displacement*

   The intermediate zone of the disc was completely displaced from between osseous articular structures. The head of condyle was in contact with the junction between posterior band of the disc and the bilaminar zone.

4. *Full displacement*

   The entire articular disc was anteriorly displaced relative to the posterior slope of the articular eminence and head of the condyle. The bilaminar zone of the disc was interposed between the osseous articular structures and occupied the narrowest joint space. The disc reduced on mouth opening.

5. *Full displacement without reduction on opening*

   Identical description to category 4, but without reduction of the disc on mouth opening.

6. *Non-categorizable disc position*

   MR images produced were of poor diagnostic quality, and could not be interpreted for disc position.

The most representative medial, lateral, and central slice as confirmed on axial scout images of the joint on which sagittal images were planned, was assigned a subjective score as outlined above (1 - 6). The most extreme lateral or medial slices were not necessarily selected for interpretation of disc position, since discal elements on these slices were not distinguishable from capsular structures in these regions[2,3]. Utilization of axial images permitted representative sagittal slices in each region of the joint to be selected for evaluation and eliminated the chance of tracing capsular elements in either the medial or lateral regions of the joint.

Closed mouth lateral cephalometric radiographs were obtained for each subject, making use of the same polyvinylsiloxane centric occlusion bite registration using a panoramic/ cephalometric combination machine (Siemens OP10). Open mouth, lateral cephalometric radiographs were also exposed to determine the shape of the head of the condyle. Subjects were instructed to gaze directly ahead into the mirror image of their pupils and to place the teeth in maximum intercuspation with the bite registration interposed.

In addition to the subjective evaluation of disc position on MRIs of the TMJ, lateral cephalometric radiographs and sagittal MR images of the joints were used to quantify disc displacement and disc length. Measurement of these disc variables was used to determine the following:

1. The position of the articular disc relative to the condyle.
2. A means of measuring disc displacement
3. A means of measuring disc length.
4. Classification of disc displacement into groups according to pattern and severity.
5. A measure of the relative medial and lateral pole displacement of the disc.

Lateral cephalometric radiographs were traced on acetate tracing film by the principal investigator, and retraced approximately two weeks later. An accurate outline of the condylar head was obtained by superimposing the closed mouth tracing of the symphysis, the lower border of mandible, developing dental follicles and enamel organ where present, on the open mouth image. The long axis of the condylar neck was determined making use of a circle-center method. Firstly, the condylar head was identified and a circle center established to describe the outline of the anterior, posterior and superior surfaces of the condylar head, this allowed separation of the condylar head from the neck region. Secondly, the long axis of the condylar neck was determined by making use of two circles. The first of these circles was spaced such that the circumference of this circle passed through the center of the condylar head circle. The successive circle produced in the condylar neck region passed through the center of the preceding circle and was confined to the outline of the condylar cortical neck region. A line joining the circle centers in the condylar neck region defined the long axis of the condylar neck. Condylar head was not included in the line defining the long axis of the neck, since great variability in condylar head morphology between subjects was evident. Identification of Porion and Inferior Orbital rim allowed for the addition of Anatomic Frankfort Horizontal plane to the tracings (Figure. 4.1). This reference plane was selected due to its proximity to the joint and was used to orientate the sagittal MRI slices of the joint to a standard reference plane.

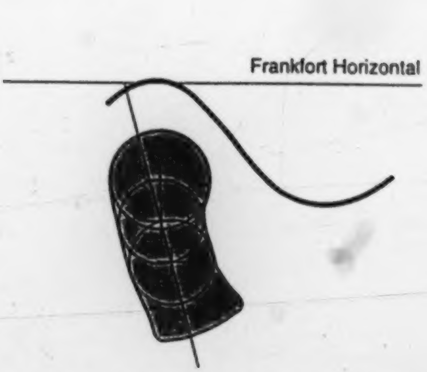


Figure 4.1: Determination of Condylar Neck Long Axis

Sagittal images of the TMJ were produced from 3 mm thick volume slices of the joint, producing 4 to 6 images per joint. Identification of soft tissue and osseous components on each sagittal slice was considered a prerequisite for inclusion of the TMJ slice in data gathering. All sagittal MRI slices were traced by principal investigator to identify the articular structures (i.e., the condyle of the mandible, articular eminence of temporal bone) as well as the articular disc (Figure. 4.2). The same method was applied to identify the long axis of the condylar neck on MR images. Subsequent superimposition of MRI tracings on lateral cephalomeric tracings along the condylar neck long axis allowed for the transfer of Frankfort Horizontal from lateral cephalometric tracings to MRI tracings. No correction for magnification was attempted since it has no effect on the accuracy of transfer of Frankfort Horizontal reference plane. In addition, the magnification difference between lateral cephalometric radiography (15%) and sagittal MRIs (12%) was small (3%).

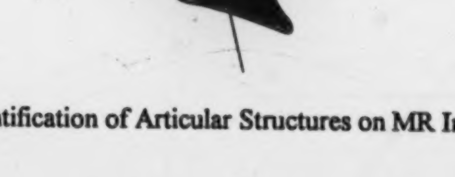


Figure 4.2: Identification of Articular Structures on MR Images

The posterior slope of the articular eminence on MR images was defined by two circles with the closest fit to the glenoid fossa and the articular tubercle, respectively. The inflection of the posterior slope of the eminence from the circle circumferences provided two points to include a single tangent to the circles, which was parallel to the articular eminence (Figure. 4.3).

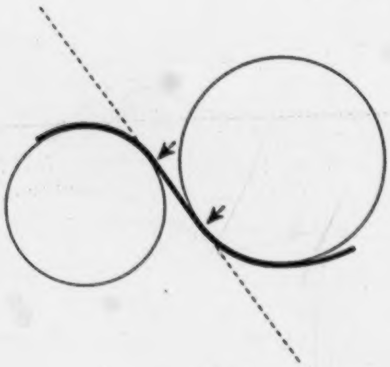


Figure 4.3: Posterior Slope of Articular Eminence

The angle formed by the plane of the posterior slope of the articular eminence to Frankfort Horizontal was measured. An evaluation of 150 MR images of the TMJ showed that the mean angle between the posterior slope of the articular eminence plane and Frankfort Horizontal plane was $50.2^0$ (Range $38^0$ to $72^0$, standard deviation $11.3^0$). A mean reference plane of $50^0$ was established as the "longest posterior slope of the articular eminence." This Eminence Reference Plane of $50^0$ to Frankfort Horizontal was applied to all traced slices of the TMJ, at a point 10 mm anterior to the maximum height of the glenoid fossa, along the Frankfort Horizontal plane (Figure. 4.4). A standardized Eminence Reference plane was considered desirable due to variability of slope of the articular eminence between patients and within patients, in different regions of the joint.

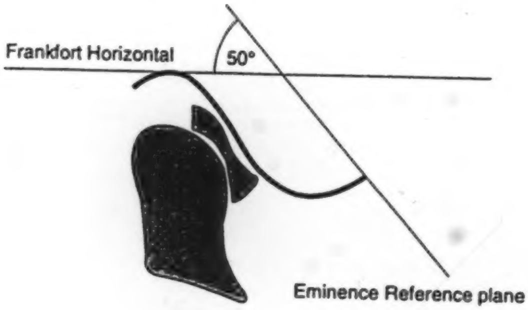
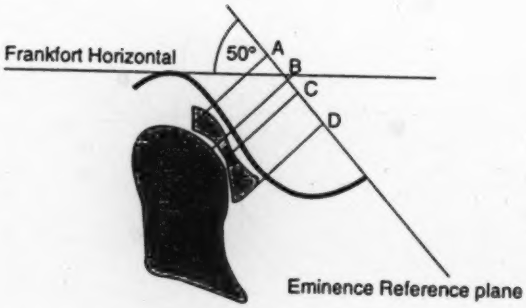


Figure 4.4: Established Eminence Reference Plane

The outline of the articular disc, the midpoint on the most anterior bulge on the anterior band, the midpoint on the most posterior bulge of the posterior band, as well as the midpoint of the intermediate zone of the disc were defined. A perpendicular from each of these points, projected to the Eminence Reference Plane, provided the relative position of the disc to the reference plane. This served as a measure of the position of the disc relative to the articular eminence, and allowed for linear measurement of disc length.

The closest joint space between the head of the condyle and the posterior slope of the articular eminence was identified and marked on the outline of the condylar head. This point served as the "Condylar Load Reference Point." A perpendicular from this point to the Eminence Reference Plane marked the position of the Condylar Reference Point relative to the articular eminence plane (Figure. 4.5). A perpendicular orientation was chosen because condylar loading has been considered to be perpendicular to the articular eminence in the closed mouth position[4,22,23].



**A**: Posterior band of disc **B**: Condylar load point **C**: Discal midpoint **D**: Anterior band of disc

Figure 4.5: Intra-articular Reference Points Relative to Eminence Reference Plane

The closest joint space between the head of the condyle and posterior slope of the articular eminence was considered to be the functional load area of the joint when the teeth are in maximal intercuspation. In the normal joint, the posterior band swells into the joint space posterior to the closest joint space, while the anterior band conforms to the anterior joint space. The thin intermediate zone of the disc fills the closest joint space and is located midway between the anterior and posterior bands of the articular disc[24]. In the normal joint the condylar load point and the discal midpoint should be in close approximation to one another. As the disc is progressively displaced anteriorly, these points become progressively separated. Measurement of disc displacement from the condylar load point is thus possible along the Eminence Reference Plane when the teeth are in a static intercuspal relationship.

Measurement of disc displacement (distance B to C in Figure 4.5) and disc length (distance A to D in Figure 4.5) was carried out making use of a Mitutoyo digital caliper accurate to 0.01 mm (Mitutoyo Canada Inc. Ontario, Canada). The ratio of the two measurements was calculated as disc displacement / disc length.

### 4.3 Error of Method

Reliability in obtaining Frankfort Horizontal and condylar long axis on lateral cephalometric radiographs was computed by randomly selecting twenty-five radiographs and retracing the landmarks. Magnetic resonance images corresponding to the randomly selected radiographs were similarly retraced to determine reliability of obtaining condylar long axis and eminence reference plane on MR images. Dahlberg's formula[25] for determination of the standard error was applied for double determinations, and the standard errors expressed in degrees.

Dahlberg's Formula $S_e^{\,2} = \Sigma d^2/2n$

Where $S_e$ is the standard deviation of the differences of each of the replicates from the mean; $n$ is the number of radiographs retraced; and $d$ is the difference between the first and the second recordings.

Determination of intra-rater reliability in measurement of disc length and degree of disc displacement was determined by selecting ten MRIs representative of normal disc position, and ten representative of disc displacement. These twenty MRIs were retraced five times each on consecutive days to determine the error of measurement. Each day the MRI's were randomly ordered and traced. All identification names or numbers were concealed from the observer. Multivariate ANOVA procedure with MRIs and tracings as factors were utilized to generate a F- statistic and determine the coefficient of intra-rater reliability (Rel = 1-1/F) for disc length and disc displacement[26]. F-statistic measures the significance of between tracing variability, so 1-1/F will measure within tracing variability relative to total variability.

### 4.4 Analysis of Data

Discriminant analysis is generally used to establish whether recorded variables correctly classify subjects according to a known classification scheme. In this way discriminant analysis was employed using SPSS for Windows (SPSS Inc. Chicago, IL) to determine if the

TMJ variables (i.e. disc length, disc displacement, and ratio), could be used to classify joints into the 5 categories of disc position according to subjective evaluation. For this analysis, information on a total of 912 slices were available.

The general approach, as with regression analysis, was to construct an optimal linear combination of the variables that could be applied to the classification. This linear equation provided maximum discrimination between the categories of disc position. That is to say, the function of the linear equation produced a value that had greater between group variation than the variation of values within the groups. This approach is similar to the reasoning that is applied in analysis-of-variance procedures. The ratio of the between group variation : within group variation, was used as a measure of discriminatory power[27].

In discriminant analysis the first canonical variate, or discriminant function, is that single weighted composite which of all possible weighted composites provides maximum average separation between the joint categories relative to variability within the categories. In the case of several categories, one weighted combination of the scores may distinguish well between certain categories but not between others. In such instances, a second or even third composite may be required to distinguish between categories that were not well separated by the first discriminant function. The maximum number of potential discriminant functions is equal to the number of variables $p$ or to 1 less than the number of categories, $k$ -1, whichever is smaller[28].

A cross-validation method was used to test the performance of the discriminant function. This procedure allowed the mis-classification error to be computed by reclassifying the 912 slices.

### 4.4.1 Classification Rule

Subjective evaluation was determined for the most representative medial, central and lateral slice for each joint (a total of 912 sagittal slices). Any additional sagittal MRI slices were not assigned a subjective evaluation (a total of 669 sagittal slices). In instances where no subjective evaluation of disc data was available to categorize the joints, the classification rule was applied. The classification rule was derived by making use of all slice information and constructing a classification map (Figure. 4.6). The classification map is based on discriminant scores $S_1$ and $S_2$ which were calculated making use of discriminant coefficients generated by the first and second canonical discriminant functions. The steps necessary to perform the disc classification rule on unclassified disc data are outlined below:

Step 1: Let X,Y, and Z be the scores for disc displacement, disc length, and ratio respectively. Make use of the discriminant coefficients provided by the discriminant analysis together with the measured X,Y,and Z values to compute the discriminant scores $S_1$ and $S_2$,

where $\mathbf{S_1 = 0.262 + (0.815 \times X) + (-0.261 \times Y) + (0.377 \times Z)}$

and $\mathbf{S_2 = -0.338 + (-0.774 \times X) + (0.062 \times Y) + (4.261 \times Z)}$

Step 2: Calculated discriminant scores $S_1$ and $S_2$ are plotted on the classification map. $S_1$ is plotted on the X axis and $S_2$ on the Y axis. If the point of intersection of $S_1$ and $S_2$ lies in the region enclosed by 1's, the joint is classified to category 1. Similarly, a joint in category 2 has an intercept of $S_1$ and $S_2$ falling in the region surrounded by 2's, and so on.

```
                          Canonical Discriminant Function 2
     -6.0      -4.0      -2.0       0.0       2.0       4.0       6.0
       +---------+---------+---------+---------+---------+---------+
  6.0 +                                   15                        +
      I                                   15                        I
      I                                  125                        I
      I                                 1225                        I
      I                                 12 25                       I
      I                                12  25                       I
  4.0 +          +         +         +12  2345 +         +          +
      I                               12  23445                     I
      I                              12  23 3445                    I
      I                             12   23 34 45                   I
      I                            12   23  34  45                  I
      I                            12   23  34   45                 I
  2.0 +          +         +      12 + 23   34 +  45     +          +
      I                          12    23   34     45               I
      I                         12    23    34      45              I
      I                         12    23    34       45       *     I
      I                        12    23     34        45            I
      I                  *    12     23     34         45           I
   .0 +          +         + *12    23      34 +        455         +
      I                      12     23      34           445        I
      I                     12     23  *    34    *        45       I
      I                    12      23       34              45      I
      I                    12     23         34              45     I
      I                   12      23         34               45    I
 -2.0 +          +       12+     23  +       34+         +     45   +
      I                  12      23          34                 45  I
      I                 12      23           34                  45 I
      I                12       23           34                   45I
      I               12       23            34                    4I
      I               12       23            34                     I
 -4.0 +          +   12    +  23     +       34+         +          +
      I             12        23             34                     I
      I            12        23              34                     I
      I            12        23              34                     I
      I           12        23               34                     I
      I          12         23                34                    I
 -6.0 +          12        23                 34                    +
       +---------+---------+---------+---------+---------+---------+
     -6.0      -4.0      -2.0       0.0       2.0       4.0       6.0
     Canonical Discriminant Function 1
```

Figure 4.6 : Classification Map for Discriminant Rule

### 4.5 Results

Standard errors of measurement in determination of cephalometric and MRI reference planes are presented in Table 4.1. The standard error varied from 0.66° for obtaining Frankfort horizontal on cephalographs to 1.17° for measurements of the eminence reference plane on MRIs. Coefficients of intra-rater reliability (Rel = 1-1/F) for disc length and disc displacement are presented in Table 4.2 along with the minimum and maximum standard deviations for each test variable. Maximum standard deviation in determination of both disc length and disc displacement were less than 0.5 mm.

| **Variable Tested** | **Standard Error (mm)** |
|---|---|
| Cephalometric condylar long axis | **0.933** |
| Cephalometric Frankfort horizontal | **0.661** |
| MRI condylar long axis | **1.046** |
| MRI eminence reference plane | **1.165** |

Table 4.1: Error of Method in determination of Reference planes.

| **Test Variable** | **Rel = 1 - 1/F** | **Standard Deviation (min - max)** |
|---|---|---|
| disc displacement (mm) | **1.00** | **0.05 - 0.33 mm** |
| disc length (mm) | **.98** | **0.07 - 0.47 mm** |

Table 4.2: Reliability of Repeated Measures

The discriminant analysis used quantitative information on disc length, disc displacement, and ratio of these variables for each slice. The best linear discriminant rule (Fisher's Linear

Discriminant Rule) was constructed with five groups as defined by subjective grouping. This rule is obtained by first constructing a best linear combination of disc length, disc displacement and ratio in such a way that distance between the five groups will be at a maximum with respect to these scores. Table 4.3 gives the coefficients for the first and second canonical discriminant functions.

| | **Canonical Discriminant Coefficients** | |
|---|---|---|
| | **First Function** | **Second Function** |
| Disc Displacement | 0.815 | -0.774 |
| Disc Length | -0.261 | 0.062 |
| Ratio | 0.377 | 4.261 |
| Constant | 0.262 | -0.338 |

Table 4.3: Canonical Discriminant Function Coefficients

The results of the cross-validation study which reveal the extent of mis-classification by the discriminant analysis are presented in Table 4.4. From the above table it may be calculated that there is 69.3% agreement between subjective and the discriminant classification. The descriptive measures (mean, standard deviation, minimum and maximum) for the three variables in the five discriminant categories are given in Table 4.5. The progressive shortening of the articular disc associated with an increased degree of disc displacement is illustrated in Figure 4.7.

Discriminant function and calculated discriminant scores were used to categorize the remaining unclassified slices which were not subjectively classified. The classification rule allowed these slices to be classified into the discriminant categories as illustrated in Table 4.6.

| **Discriminant Category** | **Subjective Grouping** | | | | | **Total** |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | |
| **1** | 220 | 48 | 1 | - | - | 269 |
| **2** | 82 | 134 | 25 | - | - | 241 |
| **3** | 2 | 18 | 77 | 23 | - | 120 |
| **4** | - | 1 | 31 | 114 | 29 | 175 |
| **5** | - | - | - | 20 | 87 | 107 |
| **Total** | 304 | 201 | 134 | 157 | 116 | 912 |
| **Correct** | 220 | 134 | 77 | 114 | 87 | |
| **Percent** | 72 | 67 | 57 | 73 | 75 | 69.3 |

Number of Missing Observations: 0

Table 4.4 : MRI Slice Allocation according to Discriminant Function

| | | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 |
|---|---|---|---|---|---|---|
| | No. | 269 | 241 | 120 | 175 | 107 |
| Disc Length | mean | 10.27 | 10.30 | 9.28 | 7.53 | 4.70 |
| | min | 5.33 | 5.98 | 4.90 | 2.66 | 1.54 |
| | max | 14.86 | 14.75 | 13.73 | 12.30 | 7.80 |
| | SD | 1.36 | 1.50 | 1.89 | 1.75 | 1.38 |
| Disc Displacement | mean | -0.31 | 1.15 | 3.01 | 4.93 | 6.97 |
| | min | -3.26 | 0.46 | 1.29 | 2.20 | 3.34 |
| | max | 0.52 | 2.81 | 4.96 | 8.25 | 10.77 |
| | SD | 0.64 | 0.48 | 0.88 | 1.10 | 1.50 |
| Ratio | mean | -0.03 | 0.11 | 0.33 | 0.68 | 1.59 |
| | min | -0.22 | 0.05 | 0.17 | 0.48 | 1.03 |
| | max | 0.07 | 0.23 | 0.50 | 1.08 | 4.60 |
| | SD | 0.06 | 0.04 | 0.09 | 0.16 | 0.53 |

Table 4.5 : Descriptive Variables for Discriminant Categories.

| | Discriminant Grouping | | | | |
|---|---|---|---|---|---|
| | **Group 1** | **Group 2** | **Group 3** | **Group 4** | **Group 5** |
| **Slice Allocation** | 331 | 108 | 85 | 89 | 56 |

Table 4.6: Discriminant Grouping of Unclassified Slices

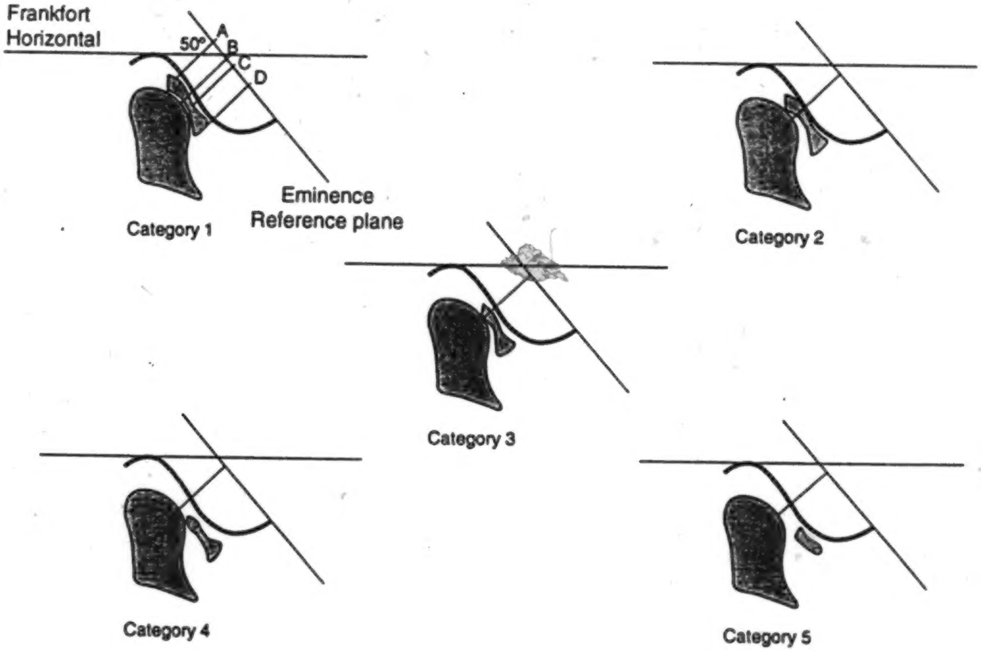

Frankfort
Horizontal
50°
A
B
C
D
Eminence
Reference plane
Category 1
Category 2
Category 3
Category 4
Category 5

Figure 4.7 : Categories of Disc Status

### 4.6 Discussion

Previous attempts at quantification of disc displacement have made use of the twelve o'clock position to determine the location of the disc relative to the head of the condyle. The inadequacies of this technique and its inability to identify functional disc position, prompted our investigation into a functional assessment of disc position relative to the osseous articular elements of the TMJ. Since subjective interpretation of disc position on MRI is a currently accepted clinical standard, this form of evaluation was chosen as a basis for quantification of disc status.

The present study made use of a standardized reference plane (Eminence reference plane) throughout the joint which allowed for standardization of MRI slice and joint position. A test model was constructed which allowed for the Eminence reference plane to rotate about the point of intersection with the Frankfort Horizontal plane. A difference in measurement of disc length of 1 mm relative to the $50^0$ Eminence reference plane was found when the Eminence reference plane was rotated through $\pm 25^0$. Therefore, any natural variation in the anatomical slope of the eminence within ($50^0 \pm 25^0$) would be accommodated by using the standardized Eminence reference plane for measurement of disc length. This model shows that the standardized Eminence reference plane may not coincide exactly with the anatomical inclination of the posterior slope of the eminence throughout the joint but is an adequate approximation of the slope and allows the functional joint components to be related to one another.

On MR imaging, the disc was identified as the relatively low signal soft tissue structure occupying the joint space on $T_1$-weighted images. The relatively high signal intensity of fibrocartilage covering the temporal bone and the condyle allowed for differentiation between the low signal of compact bone from that of the disc[12]. Signal intensity within the disc showed some variability according to the degree and direction of disc displacement, but was generally of sufficient quality to allow for identification of the various discal regions. Once identified, it was possible to project the various discal regions and condylar load point onto the established reference plane for quantitative assessment of disc length and disc displacement according to standardized criteria. In this way TMJ information was gathered on consecutive slices in each joint.

Discriminant analysis revealed that all three independent variables were descriptive and discriminant for grouping the slice data into the pre-established subjective categories. Cross-validation was performed and mis-classification errors were computed making use of 912 classified slices. Discriminant analysis correctly allocated 69.3% of the quantitative data to the subjectively classified categories. Using this discriminant function and quantification technique, it is possible to correctly assign disc position to one of five categories of disc status approximately 70% of the time when experienced maxillofacial radiologists' subjective criteria are taken as the standard for comparison. The results of this study provide adequate and much needed quantitative information regarding disc status.

Descriptive statistics were computed for each of the independent variables, this revealed a reduction in disc length associated with increased severity of disc displacement. There appeared to be an inverse relationship between disc length and severity of disc displacement. Although not specifically quantified in previous literature or studies, numerous authors have observed a similar association between disc length and disc displacement.

A reduction in disc length has been reported by Larheim[29], and Westesson *et al*[30], when they independently reported on disc deformation occurring with disc displacement. Degenerative remodeling of the posterior band of the displaced disc has been observed by Isberg *et al*[31], and Luder[32]. Discal atrophy has been shown to occur in association with degenerative remodeling as the disc is no longer hydrated as a consequence of normal function[33]. Functional impairment of the disc may lead to disc resorption and shrinkage, or the body may respond by producing fibrosis of the posterior discal attachment and displaced disc[17,24]. Bjornland

and Refsum[34] reported a complete disappearance of the articular disc in cases of chronic non-reducing disc displacement and in joints affected by rheumatoid arthritis. Buckling of the disc was also observed in cases exhibiting full anterior disc displacement, and may have contributed to a relative shortening of the disc.

When the disc is displaced, the retrodiscal tissue interposed between condyle and temporal bone undergoes remodeling and a decrease in vascularity[35]. As this occurs regions of the disc may change to a mixed signal intensity on MRI making interpretation of some disc displacements difficult[36]. Signal intensity changes correspond to an altered distribution pattern of proteoglycans and water, which are thought to change as a result of altered loading patterns[21,37]. Even though remodeling and fibrosis of the retrodiscal tissues changes the MR signal in this area, so that it is less distinguishable from the posterior band of the disc, there was nevertheless a notable reduction in overall disc length in joints with full disc displacement. To the authors' knowledge, this is the first study to quantify the association between disc displacement and disc length.

Variability in disc length within each discriminant category was noted and may have been due to differences in sagittal disc length in various regions of the joint. That is, in the medial or lateral region of the joint the antero-posterior length of the disc may be shorter than in the central region of the joint as a result of anatomical differences. In addition, disc length may have varied as a consequence of age differences between the individuals sampled or as a result of differences in relative size between individuals. Regardless of the variability in disc length, an association between increased disc displacement and a reduction in disc length was shown.

Assessment of coronal images identified the presence of sideways disc displacement. Initial evaluation of the sagittal images corresponding to the joints with sideways displacement revealed joints with "empty fossae[3]." On closer examination a low signal band was identified in the anterior joint space region. This was interpreted to be a stretched discal attachment that was in communication with the medial or laterally sideways displaced disc, through the anterior joint compartment.

Innate difficulties in the design and application of this linear measurement technique were encountered. Limitations in design were as follows:

- From the onset, the normal relationship of the articular disc to the condyle and articular eminence was based on currently accepted classification of disc position[21].
- Extreme medial and lateral MRI slices may represent capsular components of the joint, and not accurately depict discal elements.
- All measurements were made by the same investigator.

Difficulties in the application of the method were as follows:

- There was great inter-subject variability in Frankfort Horizontal, as determined from lateral cephalometric radiographs.
- An average condylar neck and head shape per subject was determined due to imperfect superimposition of left and right condylar structures on lateral cephalometric radiology.
- Remodeling of the retrodiscal tissue in cases of disc displacement increased the variability in identification of the posterior band.
- Loss of disc morphology with disc displacement made it difficult to identify the intermediate zone of the disc. Instead, the midpoint of the disc was selected to represent the intermediate zone.
- Change in morphology in the head of the condyle may challenge the observer in assigning the condylar load point.
- No repeat MR images were taken to verify that muscle contraction did not affect disc or condylar position in either the open or closed mouth position.

Imaging techniques have become increasingly refined, providing excellent spatial and contrast resolution of tissues. Sophisticated imaging techniques require adequate evaluation and interpretation. The ability to quantify disc status according to discriminant analysis may further our understanding of the associations between morphologic alterations of the articular disc, TMJ disorders, craniomandibular disorders, and patient symptoms. This analysis will be tested for intra- and inter-rater reliability, and will be used to describe disc position both quantitatively and qualitatively in an adolescent population.

## 4.7 Conclusions

Discriminant analysis may be used to categorize disc status when disc length, disc displacement, and ratio measurements are used as variables. In this analysis an increased severity of anterior disc displacement was associated with a reduced anteroposterior disc length. In the future, reconstruction of the sagittal segmental slices in the frontal plane will allow an appreciation of the pattern of disc displacement in a particular joint. This method of interpretation of joint structures will allow qualitative and quantitative description of joint status and accommodate disc displacements not depicted in the sagittal plane of imaging.

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# CHAPTER 5

## Observer Variation in Quantitative MRI Assessment of TMJ Disc Status

### 5.1 Introduction

Magnetic resonance imaging (MRI) has been employed as an imaging modality for assessment of temporomandibular joint (TMJ) soft tissue structures. MRI offers a direct form of visualization of the articular disc relative to the osseous articular surfaces, providing excellent spatial and contrast resolution of the TMJ components[1-3].

Interpretation of MRI-determined disc position has traditionally relied on subjective evaluation by experienced radiologists. More recently, specific subjective categories of disc postion have been introduced for use in classification of joints[4]. The classification techniques make use of both sagittal and coronal images to explain the three-dimensional appearance and position of the articular disc[1-3,5]. These subjective categories presume a continuous progression of disc displacement from normal disc position to eventual disc displacement without reduction.

Classification according to categorical data is highly descriptive and aids in communication of findings between observers. In addition, the formalization of structured categories with specific criteria facilitates consistent interpretation and systematic appraisal which may help determine the prevalence and incidence of a disorder. More importantly, reliability and reproducibility studies on these classification techniques have tested the intra- and interobserver variability and have proved to be acceptable when tested with Kappa statistics for categorical data[5,6].

Quantification of disc position on MRIs of the TMJ has been attempted[7,8] in preference to qualitative subjective description. Reliability and reproducibility of the quantification techniques are, however, poorly tested. Drace and Enzmann[7] measured the angular displacement of the posterior band of the disc relative to the twelve o'clock position on the condylar head. In this study intra- and interobserver variation was cited to be less than ± $5^0$, but the number of observers and method of investigation were not stated.

More recently projective geometry has been used to predict the relationship between the condyle, disc and fossa in a normal population[8]. This technique does not make use of conventional linear or angular measurements to define disc position, but uses ratios of areas defined by three points in a mathematical equation. Unfortunately this study was conducted on only normal subjects and no interobserver reliability measures were performed. Therefore it appears that methods for quantification of disc position on MRIs of the TMJ may lack reliability and reproducibility, and cannot replace subjective categorical classification techniques.

Subjective evaluation of images has been shown to be adequate for clinical purposes and hypothesis testing, but allows only for generation of categorical data. The production of continuous data would be more appropriate, allowing the full potential of MRI of the TMJ to be appreciated. A new technique has been developed which quantifies disc position and disc length, describing disc status in terms of continuous linear measurements. Cross-validation and mis-classification errors of the technique have been tested and intraobserver reliability measures have been conducted[9]. However the interobserver reproducibility and reliability, making use of observers unfamiliar with the technique, have not been tested. Therefore, the purpose of this study was to investigate the interobserver agreement in the application of a new technique developed for the quantification of TMJ disc status using MR images.

## 5.2 Methods and Materials

As part of a screening evaluation of TMJ status, 194 adolescent subjects (males and females) between the ages of 10 and 17 years underwent MRI of the TMJs. All individuals consented to inclusion in the study, which was approved by the Joint Dentistry/ Pharmacy Human Ethics Committee. Bilateral MR images of the TMJs were performed making use of a 1.0 Tesla magnet (Shimadzu Corporation, Tokyo, Japan) and a unilateral 3 inch surface receiver coil.

MRI axial scout images were obtained at the level of the TMJs to identify the long axis of the condyles. Coronal images were obtained parallel to the condylar long axis to aid in identification of lateral or medial disc displacements. Bilateral closed-mouth sagittal sections were obtained perpendicular to the long axis of the condyle making use of polyvinylsiloxane (President Jet-Bite, Coltene/ Whaledent Inc. Mahwah, NJ) centric occlusion bite registration. The position of the disc was determined on open mouth images by making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary mouth opening. T1-weighted 500/20 (TR ms/ TE ms) pulse sequences were performed for all coronal and sagittal slices with the slice thickness set at 3mm, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204.

Of the 388 joints imaged, thirty-five were excluded due to poor image quality or motion artifact, leaving 353 joint images. Of the remaining images, 70 were randomly selected for evaluation by a panel of four observers experienced in the interpretation of MR images of the TMJ. The panel of observers consisted of three maxillofacial dental radiologists and an orthodontist. All had different training backgrounds and had not previously worked together. An orthodontist, the principal investigator, was included as an observer after an extensive training period which included the theory of MR imaging and evaluation of MRIs of the TMJ. Each observer was asked to independently examine the MR images and provide a subjective assessment of disc position of the TMJ.

Clear acetate was adhered to the sagittal MR images, and each observer was supplied with a 0.3 mm lead pencil to trace the outline of the TMJ articular structures. Each observer traced the outline of the head of the mandibular condyle, the neck and ascending ramus; the posterior slope of the articular eminence; and the position of the articular disc on each sagittal MR slice image produced. The first ten MRIs were used for calibration purposes by each observer and were excluded from the study.

Each observer traced the anatomical landmarks specified, with particular attention to disc morphology and position. Determination of the long axis of the mandibular neck of the condyle and determination of the eminence reference plane was done by a single observer, according to a standardized procedure previously published[9]. The establishment of the eminence reference plane facilitated the quantification of disc position and disc length according to previously published criteria[9]. In this way quantitative measurements were produced for each slice traced by each observer for 60 MRIs of the TMJs.

## 5.3 Analysis of Data

Interobserver variability in identification and tracing of the articular structures was computed. A three-fold nested error of variance component model was used to analyse disc length (DL) and disc displacement (DD) data from 57 joints belonging to 47 subjects. Three joints were excluded from the original sample of 60 joints, since they were of poor diagnostic quality and could not be traced by any of the examiners. The remaining 57 joints were all included in the analysis whether all sagittal MRI slices were traced by each observer or not. This necessitated the design and utilization af an unbalanced analysis model.

Estimates of Intraclass correlation coefficients (ICC) were computed using the three-fold nested error variance component model to assess interobserver agreement in determining (DL) and (DD) by the four observers when tracing sagittal MRI slices of the TMJ. The model considered here incorporated random effects due to: subject variability; joint variability within subjects; slice variability within the joints (as well as within subjects); and observer variability. Estimates of the variance components for each of the above mentioned random effects was done using "REML" method (Restricted maximum likelihood method) incorporated in the function of the "Varcomp" (Variance component) in S-Plus statistical package (S-Plus package 1995, Statistical Science in S-Plus guide to statistical and mathematical analysis, Version 3.0, Statistical Science, Division of Mathsoft, Inc, Seattle). The above estimates were used in the formula below to compute the ICC for DL and DD measures.

$$\text{ICC} = \frac{s_p^2 + s_j^2 + s_s^2}{s_p^2 + s_j^2 + s_s^2 + s_o^2 + s_e^2}$$

where ICC = intraclass correlation coefficient

$s_p^2$ = estimate of variance component due to patient

$s_j^2$ = estimate of variance component due to joint within patient

$s_s^2$ = estimate of variance component due to slice within joint within patient

$s_o^2$ = estimate of variance component due to observers

$s_e^2$ = estimate of variance component due to sampling error

Ideally, most of the variation should be explained by slice, joint and subject (patient) differences and thus the calculated ICC should be high if the source of variation due to observers and error (residual) is low.

In addition, standard deviations of measurements (mm) recorded for disc length and disc displacement were computed for each joint from slices traced within each of the 57 joint.

This gave a standard deviation score among observers for each joint. Thereafter, the mean and range of these standard deviations over all joints were computed to obtain inferences on inter-observer variability.

## 5.4 Results

MR imaging of the TMJs with slice width selection of 3 mm generally produced four slices per joint. Each of the four observers traced the slices produced by imaging the 57 joints, three joints could however not be traced. In the absence of repeated ratings by each observer on each slice, the degree to which each observer departed from his or her usual rating tendencies could not be evaluated.

| Variables | Disc Length | Disc Displacement |
|---|---|---|
| $s_p^2$ | 1.492 | 5.104 |
| $s_j^2$ | 1.323 | 2.120 |
| $s_s^2$ | 0.673 | 0.432 |
| $s_o^2$ | 0.101 | 0.017 |
| $s_e^2$ | 1.530 | 1.569 |
| **ICC** | 0.681 | 0.830 |

Table 5.1: Esdtimates of Variance values for Disc Displacement and Disc Length

Calculated ICC for four observers tracing MRI slices of 57 joints was 0.681 for disc length, and 0.830 for disc displacement. The values derived from the three-fold nested error variance component model for calculation of ICC for disc length and disc displacement are provided in Table 5.1. Average variability amongst all observers in determination of disc length measurements was calculated to be 1.0406 mm, with a maximum of 3.11 mm. Average variability amongst all observers for measurement of disc displacement was calculated to be 0.9720 mm, with a maximum of 5.06 mm. The mean variability amongst all observers for determination of either quantitative variable was therefore approximately 1.00 mm (Table 5.2).

| | **$\text{Mean}_{SD}$** | **$\text{Minimum}_{SD}$** | **$\text{Maximum}_{SD}$** |
|---|---|---|---|
| **Disc Length** | 1.041 | 0.25 | 3.11 |
| **Disc Displacement** | 0.972 | 0.33 | 5.06 |

$^{*}{}_{SD}$ - denotes standard deviation taken over observers

Table 5.2: Inter-Observer Variability in Measurement of Disc Displacement and Disc Length

## 5.5 Discussion

Three-fold nested error variance component analysis was used to test the hypothesis that the differences amongst observers in measurement of disc status is equal to zero. Determination of interobserver agreement making use of this model was used to generate the component estimates of variance. Intraclass correlation coefficients (ICC) showed almost perfect inter-observer agreement (0.820) in identification and tracing of points necessary to define disc displacement. This was not true for determination of disc length measurements, in which case only substantial agreement (0.681) between observers was evident. Interpretation of ICC calculations in isolation, however, do not adequately indicate the magnitude of the difference amongst observers because no units of measurement are associated with these computed values.

The mean variability amongst all observers for determination of disc length was calculated to be 1.041 mm, with a maximum of 3.11 mm. The mean variability amongst the four observers in determination of disc displacement was calculated to be 0.972 mm, with a

maximum of 5.06 mm. While the calculated ICC for disc length was only 0.681, the mean variability amongst all observers was only slightly more than 1 mm. This means that if any observer had to trace a single slice, the tracing would differ from another observers' tracing by approximately 1 mm on average, with a maximal difference of 3.11 mm.
An ICC of 0.681 indicates that variation due to differences in MRI slices within joints within subjects accounted for 68.1% of the disc length variability, the other 31.9% was due to observer variability and error (residual) variability that could not be explained. This would suggest that observers had different interpretations in the position or shape of the anterior and posterior band of the disc. Slight differences in tracings of these regions of the disc can increase the variability in disc measurements.

Determination of ICC for disc displacement was higher at 0.830. This suggests that observers were relatively consistent in identifying landmarks essential for the determination of disc displacement.

Whether disc length or disc displacement is considered, this study clearly indicates that by making use of the measurement technique previously described[9], interobserver variabiliy is relatively low with between observers' variability averaging near 1 mm, for either variable measured. Improvements in interobserver variability may be achieved by:

- Having observers who have previously worked and trained together rate the slices,
- Allowing observers to become familiar with the technique and tracing procedure,
- Improving the quality and contrast of MR images produced,
- Applying the quantitative technique to MR images obtained from an adult population where less motion artifact may be evident due to increased cooperation.

## 5.6 Conclusions

Intraclass correlation coefficient (ICC) calculations for determination of disc displacement and disc length on MR images of the TMJ by four observers showed substantial to almost total agreement amongst observers. This indicates that this new quantitative technique for assessment of disc status can be applied by multiple observers with different training backgrounds, who are unfamiliar with the technique. Regardless of these limitations, a high degree of interobserver agreement in interpretation may be achieved.

## 5.7 References

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# CHAPTER 6

## Prevalence of Disc Displacement in the Adolescent Sample

### 6.1 Introduction

Traditionally, the prevalence of a disease or disorder is established making use of epidemiological studies with random selection of large samples of individuals with and without a disorder of interest[1]. The prevalence of temporomandibular joint dysfunction (TMD) in the adolescent population has been reported previously[2-4] and varies considerably depending on the sample selection, the criteria used to define disc displacement and the type of study conducted.

Until recently, a clinical evaluation of joint sounds has been used as a standard to determine the prevalence of TMD. Joint sounds were found to occur in 10.0% of a sample of 3428 grade schoolchildren between 6 and 12 years of age[2]. In another study conducted by Gazit *et al*[3], the prevalence of joint sounds in 369 individuals aged 10 to 18 years was found to be 35.8%. In a review by Mintz[5], the prevalence of joint sounds in adolescent individuals varied between 0% and 35.8%, with an average of 17%. These studies are further complicated by the findings of Egermark-Eriksson *et al*[4,6] and Nilner *et al*[7] who showed a positive association between joint sounds and aging in adolescent individuals. These findings highlight the importance of defining specific criteria for evaluation of the disorder of interest as well as defining the study population when the prevalence of a disorder is investigated.

Temporomandibular joint dysfunction (TMD) refers to a group of problems related to the craniomandibular articulation and does not refer to a single entity. Ankylosis, synovitis, capsulitis, disc condyle adhesions, disc displacements, osteoarthritis, rheumatoid arthritis, infection and neoplasia may all affect the temporomandibular joint and are classified as TMD[1]. Therefore an effort to find a universal prevalence for TMD where there is none represents a serious flaw and affects the reporting of the prevalence of the various disorders included under this broad category.

Associations between occlusal characteristics and signs and symptoms of TMD have also been attempted in the adolescent population. In a cross-sectional evaluation of 1342 subjects aged 6 to 17 years, Riolo *et al*[8] showed that a functional shift of the occlusion was negatively associated with TMJ and muscle tenderness, open bite was positively associated with TMJ and muscle tenderness, and joint noises were positively associated with Class II molar relationship. In contrast, Keeling *et al*[2] were not able to show associations between molar relationship and temporomandibular joint sounds but did show associations between joint sounds and larger maximal mouth opening, anterior dental crowding, and deeper incisor overbites. These studies made use of different criteria to categorize joints as dysfunctional or normal and the conflicting results highlight the need to establish specific parameters to define normal and abnormal joint function or TMD.

Numerous causes of TMD have been proposed, some are more readily identifiable than others. Disc displacement is a cause of TMD and is often associated with considerable suffering and loss of joint function. Disc displacement is readily identified using magnetic resonance imaging (MRI) of the joint. The technique is non-invasive, pain free, of minimal risk potential, free of ionizing radiation exposure and can be applied to both dysfunctional and control subjects[9]. The prevalence of disc displacement in the asymptomatic adult population has been shown to be approximately 30%[10-12], whereas the prevalence in symptomatic patients ranges from 77%[11] to 82%[12] when MRI was used to determine disc position. In a study to determine the prevalence of MRI determined disc displacement in 51 children between the ages of 8 and 15 years presenting with malocclusions, the prevalence of disc displacement was shown to be 11.8%[13]. Although this was a small sample of children, it did include individuals with both normal and abnormal disc position and did not rely on a sample of patients presenting for treatment of TMD related symptoms. The prevalence of disc displacement is naturally expected to be higher in patients than in asymptomatic individuals, and therefore prevalence studies should not be based on bias sample selections as may have ocurred in previous studies.

The purpose of the present study is to report on the prevalence of disc displacement in a pre-orthodontic adolescent sample drawn to determine the associations between disc displacement and craniofacial morphology. Furthermore, this study attempts to report on the prevalence of the various forms of disc displacement identified making use of a newly established and tested quantitative technique for evaluation of MRI determined disc position.

### 6.2 Methods and Materials

MRIs of the temporomandibular joints (TMJ) were obtained on 194 subjects (75 males and 119 females) between the ages of 10 and 17 years, regardless of TMJ disc position. All individuals consented to inclusion in the study which was approved by the Joint Dentistry/ Pharmacy Human Ethics Committee. One hundred and thirty eight consecutive subjects were recruited from the graduate orthodontic program at the University of Alberta and from a private orthodontic practice in the area, prior to undergoing orthodontic treatment. The group consisted of subjects with and without clinically detectable TMJ signs and symptoms (capsular pain; joint sounds; masticatory muscle tenderness; limited mandibular range of motion; deviation on opening). Practicing orthodontists in the Edmonton area were asked to screen pre-orthodontic patients for signs and symptoms of TMJ and to refer individuals with TMJ symptoms for MRI evaluation if consent was gained. A total of 56 subjects were recruited in this way. No individuals with a history of juvenile rheumatoid arthritis were included in the study.

Magnetic Resonance Imaging (MRI) of the TMJs were performed without sedation using a 1.0 T magnet (Shimadzu Corporation 3, Tokyo, Japan) and a unilateral 3 inch surface receiver coil. Axial scout images were obtained to identify the condyles. Bilateral closed-mouth sagittal sections were obtained perpendicular to the long axis of the condyle, and coronal images were obtained parallel to the condylar long axis. Closed mouth images were obtained making use of polyvinylsiloxane (President Jet-Bite, Coltene / Whaledent Inc. Mahwah, NJ, USA) centric occlusion bite registration. To prevent muscle fatique, bilateral open mouth sagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening. Subjects were instructed to rest the anterior teeth on the blades of the caliper. T1-weighted 500/20 (TR ms/ TE ms) pulse sequences were performed on all subjects using a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204.

All MR images of the joints were subjectively evaluated by an experienced maxillofacial radiologist to determine disc position from the coronal, as well as sagittal MRI slices. Of the 194 subjects imaged (388 joints), only thirty-five joints were excluded due to poor MRI quality, possibly as a result of motion artifacts. Six categories of disc position were identified, with categories 1 to 4 all exhibiting disc reduction on mouth opening:

1. *Normal disc position*

   In the closed mouth position the intermediate zone of the disc was interposed between the head of the condyle and the posterior slope of the articular eminence, with the anterior and posterior bands equally spaced on either side of the condylar load point in a bow tie appearance[14].

2. *Slight anterior displacement*

The intermediate zone of the disc was slightly anteriorly displaced from between the osseous articular components. The head of the condyle apposed the posterior band of disc.

3. *Moderate anterior displacement*

   The intermediate zone of the disc was completely displaced from between osseous articular structures. The head of condyle was in contact with the junction between posterior band of the disc and the bilaminar zone.

4. *Full displacement*

   The entire articular disc was anteriorly displaced relative to the posterior slope of the articular eminence and head of the condyle. The bilaminar zone of the disc was interposed between the osseous articular structures and occupied the narrowest joint space. The disc reduced on mouth opening.

5. *Full displacement with severe morphological alteration*

   Identical description to category 4, but without reduction of the disc on mouth opening.

6. *Non-categorizable disc position*

   MR images produced were of poor diagnostic quality, and could not be interpreted for disc position.

The subjective categorization of disc position was used in a discriminant analysis to determine whether quantitative measurements of disc length and disc displacement could be used to classify the position of the disc on each sagittal MRI slice of the joint[15]. Quantitative measures of disc length and disc displacement were obtained by making use of reference planes transferred from corresponding lateral cephalometric radiographs for each subject which aided in standardization of joint position and measurement technique[15]. Discriminant analysis revealed that categorization into the subjectively determined categories using the quantitative measures of disc length and disc displacement was feasible.

In males, 70 left joints and 68 right joints were available for analysis. In females, an equal number of right and left joints were available for analysis, namely 107. The newly defined discriminant category per slice of the joint was used to determine the degree of disc displacement in each joint. A joint was assigned to the following categories only if all slices within the joint were assigned the same discriminant category (Figure 6.1):

Category 1: Normal disc position (N)
Category 2: Slight disc displacement (SDD)
Category 3: Moderate disc displacement (MDD)
Category 4: Full disc displacement (FDD)
Category 5: Full disc displacement with severe loss of morphology (FDDM)

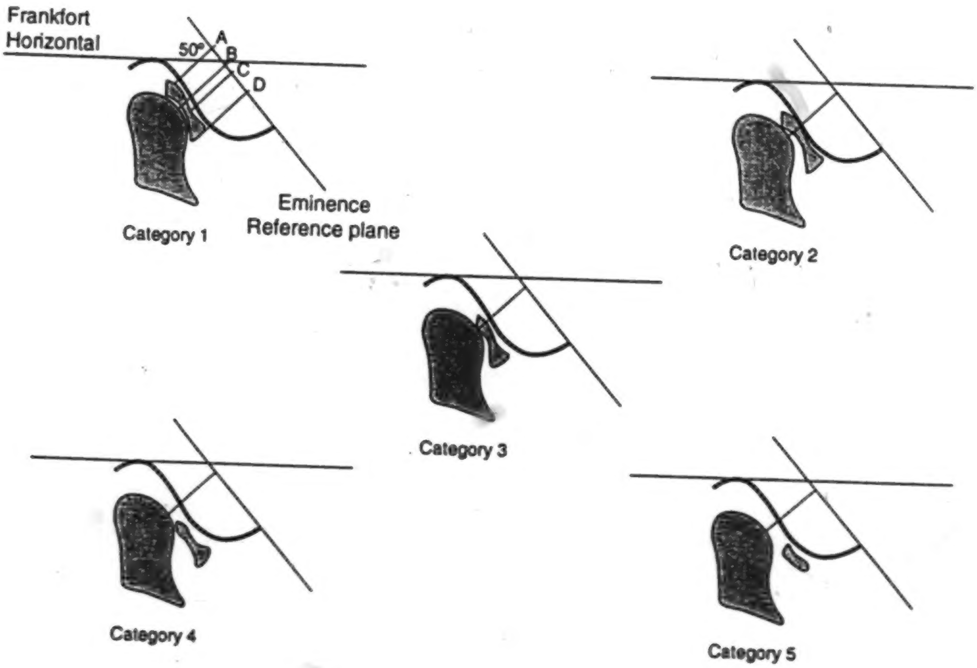
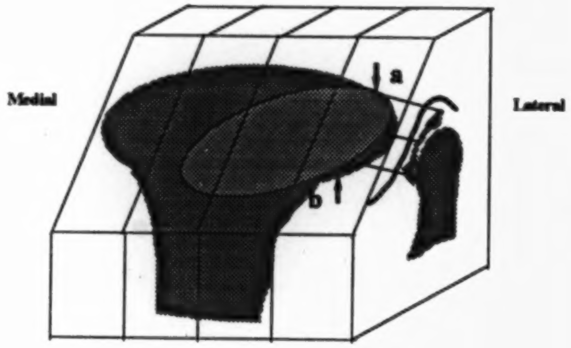

Frankfort Horizontal
50°
A
B
C
D
Eminence Reference plane
Category 1
Category 2
Category 3
Category 4
Category 5

Figure 6.1: Categories of Discriminant Disc Position

Joints which did not have a consistent discriminant score assigned to each slice throughout the joint were assigned to one of two groups:

- Antero-lateral disc displacement

The medial pole of the disc has lost its attachment or has become elongated. The degree of disc displacement in the medial part of the joint exceeds that noted in the lateral region of the joint when discriminant scores of sagittal MRI slices are taken into consideration. In this situation the bulk of the displaced disc is located in an antero-lateral position when the teeth are in intercuspation (Figure 6.2).

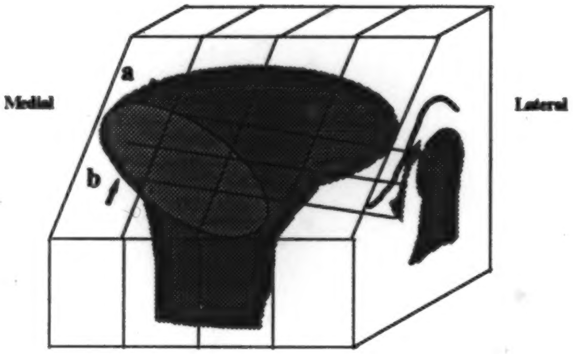


**a** : Posterior band of disc **b** : Anterior band of disc

Figure 6.2: Antero-lateral Disc Displacement

- Antero-medial disc displacement

The degree of disc displacement in the lateral region of the joint was more severe than disc displacement in the medial region of the joint as determined by discriminant score assigned. This means that the disc exhibits a rotational displacement with the bulk of the disc located in the medial region of the joint in the closed mouth position (Figure 6.3).



**a** : Posterior band of disc **b** : Anterior band of disc

Figure 6.3: Antero-medial Disc Displacement

Sideways disc displacement has recently been identified by Tasaki *et al*[12] when making use of coronal MR images. In joints affected by sideways disc displacement the articular disc is displaced either medially or laterally relative to the condyle and shows no component of anterior disc displacement. To determine the prevalence of sideways disc displacement in the current study, sagittal and coronal images were subjectively assessed to determine the presence of a sideways displacement which may have occurred in either a medial or lateral direction. No quantitative score was assigned to this type of disc displacement.

### 6.3 Data Analysis

The percentage prevalence of disc displacement was determined independently for right and left joints and separately for males and females. These data were further utilized to determine the prevalence of bilateral joint involvement making use of the discriminant categories. Unilateral normal disc position in an ipsilateral joint and contralateral disc displacement was also determined for males and females. The prevalence of bilateral or unilateral joint involvement was determined for 104 females and 68 males for whom bilateral MRI data was available.

## 6.4 Results

The percentage prevalences of normal and disc displacement according to the discriminant scores per joint are presented in Table 6.1. From these data it is evident that approximately 50% of the male joints were normal with no joint side bias. On the other hand, females with normal joints made up only approximately 26% of the female sample (Figure 6.4). It is also noted that full disc displacement with loss of morphology occured more frequently in females than males in this sample of adolescents. Within each gender, there did not appear to be any significant difference in distribution of assigned discriminant score per joint between the right and left TMJs (Figure 6.5).

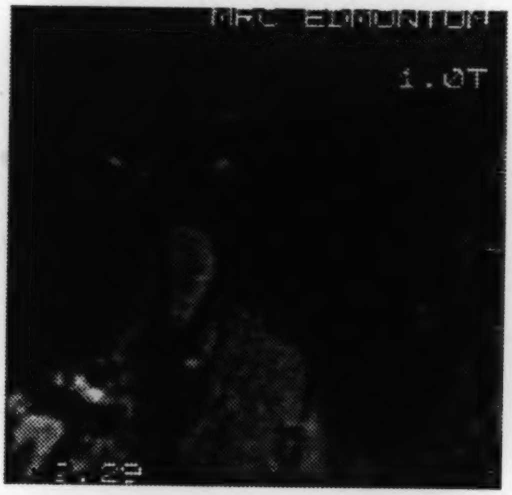


Figure 6.4: Sagittal MRI of TMJ Depicting Normal Disc Position

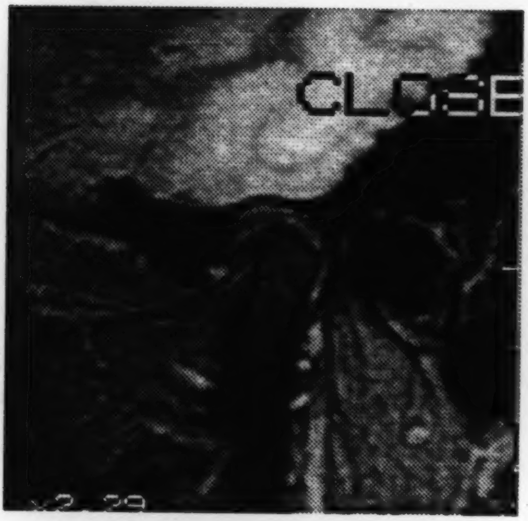


Figure 6.5: Sagittal MRI of TMJ Depicting Disc Displacement with Loss of Morphology

| **Category of Disc Position** | **Males** | | **Females** | |
|---|---|---|---|---|
| | **Left** | **Right** | **Left** | **Right** |
| Normal Disc Position | 50 | 55.9 | 26.2 | 27.1 |
| Slight DD | 12.9 | 8.8 | 14.0 | 6.5 |
| Moderate DD | 5.7 | 4.4 | 1.9 | 1.9 |
| Full DD | 7.1 | 8.8 | 12.1 | 21.5 |
| Full DD with Loss of Morphology | 2.9 | 2.9 | 14.0 | 13.1 |
| Other | 21.4 | 19.2 | 31.7 | 29.9 |

*Disc position/ joint was determined by making use of all sagittal MRI slices/ joint. All slices had to be similarly scored to be placed in one of 5 categories. Joints with slices with different scores were placed in a 6th category, "Other' which was further analysed for direction of disc displacement.

Table 6.1: Percentage Prevalence of Disc Displacement in Adolescent Sample

Bilateral normal joints were more common in males than females, while bilateral full disc displacement with loss of morphology was far more prevalent in females than males (Table 6.2). Bilateral occurrence of the intermediate stages of disc displacement was poorly represented in both males and females in this adolescent sample when only the sagittal slice information meeting requirements for discriminant categorization was assessed. The occurrence of unilateral normal disc position with contralateral disc displacement of any form was more prevalent in males at 29.4%, compared to females which showed 18.3% (Table 6.2).

| | **Joint Status** | **Males** | **Females** |
|---|---|---|---|
| Bilateral Status | Normal | 36.8 | 16 |
| | Slight DD | 3 | 1 |
| | Moderate DD | 0 | 0 |
| | Full DD | 1.5 | 5.7 |
| | Full DD with loss of Morphology | 0 | 11.3 |
| Unilateral Status | One side Normal, other side DD of any form | 29.4 | 18.3 |

* Disc position/ joint was determined by making use of all sagittal MRI slices/ joint. All joints previously classified into one of the 5 categories were used to determine bilateral classification. Unilateral joint category was determined by combining normal only joints with either moderate DD, full DD, or full DD with morphological alterations.

Table 6.2: Percentage Prevalence of Bilateral and Unilateral Disc Displacement

Regardless of joint side or gender, antero-medial disc displacement was more prevalent than antero-lateral displacement (Table 6.3). Overall, females exhibited more rotational disc displacement than males. The prevalence of sideways disc displacement for males and females as determined from coronal images of the joints is presented in Table 6.4.

| Category of Disc Position | Males |  | Females |  |
|---|---|---|---|---|
|  | Left | Right | Left | Right |
| Antero-lateral DD | 7.4 | 7.4 | 12.1 | 14.0 |
| Antero-medial DD | 14.3 | 11.8 | 19.6 | 15.8 |

* Disc position/ joint was determined by making use of all sagittal MRI slices/ joint. All joints previously classified as "Other" in Table 1 were evaluated to determine direction of disc displacement when a full category could not be assigned throughout the joint.

Table 6.3: Percentage Prevalence of Antero-medial and Antero-lateral Disc Displacement for All Joints.

| Disc Displacement | Males |  | Females |  |
|---|---|---|---|---|
|  | Right | Left | Right | Left |
| **Lateral** | 2.9 | 5.7 | 11.8 | 19.1 |
| **Medial** | 0.0 | 1.4 | 6.4 | 2.7 |

*Disc position determined by subjective evaluation of coronal MR images of joints

Table 6.4: Percentage Prevalence of Medial and Lateral Sideways Disc Displacement

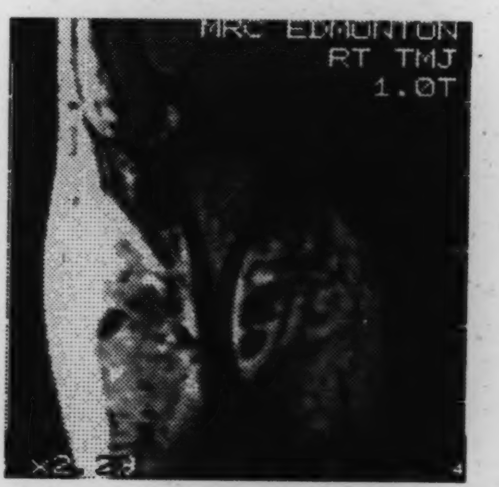


Figure 6.6: Coronal MRI of TMJ Depicting Sideways Disc Displacement

## 6.5 Discussion

This sample under consideration was recruited to determine whether MRI determined disc position could be associated with alteration in craniofacial morphology. Subjects recruited for this study included individuals with and without clinically detected signs and symptoms of TMD. It was attempted to derive a study sample based on clinical signs and symptoms which would be equally distributed between symptomatic and asymptomatic assignment. This seems to have been achieved in the male sample where approximately 50% of the males had either right or left TMJs with normal categorization. Only 36.8% of the males were however bilaterally normal according to discriminant analysis assignment of TMJ category. In females only approximately 26% of the joints were normal on either the left or right side and only 16% had bilateral normal disc position. Males exhibited 7% and 9% full disc displacement (FDD) on the left or the right hand side respectively, and approximately 3% FDDM on either side. Females showed a higher prevalence of FDD than males, with 12.1% in the left TMJ and 21.5 in the right TMJ. This was also the case for FDDM, where females exhibited over 4 times the prevalence of FDDM than males.

Bilateral disc displacement, whether FFD or FFDM, was more prevalent in females than males, but males exhibited more bilateral normal joints than females. Males seem to be more affected by unilateral joint involvement than were females. This may be related to the etiology of the displacement. In males, trauma to the mandible and joint seems to be more prevalent and this may involve the joints unilaterally whereas another mechanism may be responsible for disc displacement in females. It has been suggested in animal studies that joint laxity involving any joint occurs more commonly in females than males[16,17]. These findings may represent a sex-limited expression of joint laxity that is related to altered collagen synthesis which is affected by either the level of circulating estrogen or the concentration of estrogen receptors within joints[18]. It is suggested that individuals with joint laxity as a result of altered collagen synthesis are at greater risk of developing bilateral TMD when subjected to other etiological factors such as trauma, joint overextension or overuse[19].

Antero-medial disc displacement involving a straight anterior displacement of the lateral region of the disc and a sideways shift of the displaced lateral pole of the disc in a medial direction was shown to be more prevalent than antero-lateral disc displacement. These findings are comparable to those of Tasaki *et al*[12] who termed these displacements; partial anterior displacement of the disc in the lateral part of the joint and partial anterior displacement of the disc in the medial part of the joint, respectively. In keeping with the overall higher level of disc displacement identified in females, the prevalence of antero-medial and antero-lateral rotational disc displacements was higher in females than in males. Rotational disc displacement did not, however, show any side specific bias in either males or females. These forms of rotational disc displacement were the most prevalent of all forms of displacement identified. This may be an indication that a disc displacement in a single region of the joint is common compared to disc displacement throughout the joint needed to satisfy the strict discriminant categories of disc displacement.

Antero-medial or antero-lateral disc displacement may be viewed as a form of slight or moderate disc displacement if the functional effects of disc displacement are considered. A rotational disc displacement functions similarly to a slight or moderately displaced disc, in that during some phase of the masticatory cycle the disc is displaced, while during another phase the disc is once more interposed between the osseous articular surfaces. Rotational displacements may be an intermediate stage of disc displacement where only one collateral discal ligament is elongated, the other collateral ligament may not have elongated sufficiently yet to allow for the developed of full disc displacement throughout the joint. If antero-medial and antero-lateral displacements are considered as slight or moderate disc displacements, then it may be appreciated that these two categories do form a continuum in the distribution of disc displacements identified.

The prevalence of sideways disc displacement in females was higher than in males and was more common in a lateral direction as identified by a lateral bulging of the joint capsule on coronal MR images. Lateral sideways disc displacement was more prevalent in the left TMJ than the right for both males and females, while medial sideways disc displacement was more common in the right TMJ. Only one male exhibited medial sideways disc displacement and this affected a left TMJ. In joints with a sideways component to the disc displacement the sagittal MR images did contain an area of reduced signal intensity anterior to the condyle, inferior to the height of the articular eminence, superior to the lateral pterygoid muscle insertion into the condyle neck, in the anterior joint recess. This area of reduced signal intensity was interpreted to be the elongated medial or lateral collateral discal ligament maintaining communication with the displaced disc and the corresponding condylar pole of attachment.

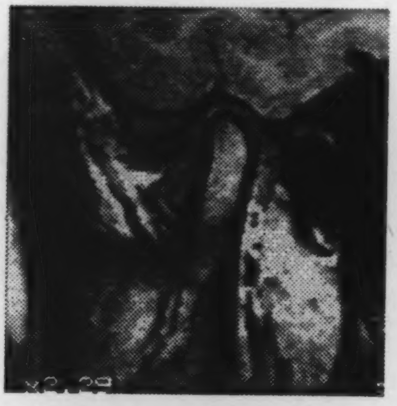


Figure 6.7: Sagittal MRI of TMJ Depicting Elongated Collateral Ligament Associated with Sideways Disc Displacement

The prevalence of medial sideways disc displacement for males in this study is significantly less than that previously reported by Tasaki *et al*[12] in their evaluation of patients and symptom free individuals. In addition, the present study reports significantly higher prevalence of lateral sideways disc displacement in females, compared to to the findings of Tasaki *et al*[12]. The age of the individuals included in the respective studies may be a factor responsible for the differences observed between the two studies.

The prevalence of disc displacement identified in this sample of adolescent individuals should not be extrapolated to the general orthodontic population or to the population at large. This study is not representative of these populations since it was not selected on a random basis. The study does however recognize that disc displacement is prevalent in the adolescent population and is more prevalent in the female sample. The present study shows that disc displacement involving the TMJ affects individuals presenting for orthodontic consultation. Disc displacement may be associated with altered facial morphology or malocclusion which may be a clinical treatment challenge if normal facial growth is affected by the disc displacement. Furthermore, disc displacement may be associated with the development of clinical symptoms of craniofacial pain once the adaptive capacity of the joints is reduced when active growth is completed. A failure to identify individuals with disc displacement may have medicolegal implications if symptoms appear once orthodontic treatment has been completed. In addition, the use of only sagittal MRI slice information may not identify the full prevalence of disc displacement, since lateral or medial sideways disc displacements, as seen on coronal MR images, may not be visualized on the sagittal images.

## 6.6 Conclusions

The prevalence of disc displacement in this study sample of pre-orthodontic adolescent individuals was shown to be higher in females than in males. Unilateral disc displacement was more common in males than females but no side specific bias in the prevalence of disc displacement was identified. Antero-medial disc displacement was shown to occur more commonly than antero-lateral disc displacement. These rotational disc displacements were the most common form of disc displacement affecting joints and are most likely included in the moderate disc displacement group.

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# CHAPTER 7

## Female Adolescent Craniofacial Morphology Associated with Advanced Bilateral TMJ Disc Displacement

### 7.1 Introduction

Cephalometrics was developed as a means of quantifying facial proportions and dimensions and monitoring growth alterations during development or treatment. Cephalometrics is capable of identifying alterations in specific regions of the face that may be of significance in normal craniofacial development. During normal growth, equilibrium between the various facial components is maintained with harmonious development of the various regions involved. Alterations in normal growth may occur in any of the facial components, causing imbalance and loss of normal craniofacial harmony.

A number of specific factors are identified as being associated with altered craniofacial morphology. Linder-Aronson[1,2] demonstrated that the patency of the nasal airway is of great importance in the three-dimensional development of the face. Nasal obstruction is accompanied by an alteration in the mode of respiration, an alteration in the pattern and strength of masticatory muscle function, with an eventual alteration in the direction of mandibular growth expression. Correction of nasal obstruction and mode of respiration allowed for mandibular growth to resume a more natural counter-clockwise direction of growth[3,4].

Localized condylar fracture, infection and ankylosis disturbs the physiology, structure, and function of the temporomandibular joint (TMJ). In addition, functional musculature surrounding the joint may be involved, further affecting the normal expression of condylar growth. It is generally accepted that the mandibular condyle is not a growth centre, but rather a growth site which is adaptive in nature, responding to physical, environmental, and hormonal influences[5]. Interference in the normal adaptive capacity of the condyle, which contributes to development of the ramus and corpus of the mandible, has been shown to result in facial asymmetry[6,7]. Moreover, bilateral involvement of the condyles produces varying degrees of retrognathia of the mandible[8].

Bjork[9] was able to observe the effects of bilateral condylar hypoplasia on facial development in adolescents by making use of vitallium implants as fixed reference markers. These individuals were followed longitudinally, and developed severe facial abnormalities characterized by mandibular retrognathia, reduction in posterior facial height, increased divergence of the facial planes toward the anterior region of the face, and increased facial convexity. A reduction in the contribution of the condyles to development of the ramus and mandible was demonstrated, although the effect of altered muscle function and patency of the airways could not be analysed.

Juvenile rheumatoid arthritis is a group of disorders with chronic synovitis persistent for at least 6 weeks in one or more joints as a common denominator, with an onset before the age of 16 years[10]. This inflammatory synovitis has been shown to affect the TMJs and may be implicated in altered craniofacial morphology[11-13]. The term "bird faces" was coined to describe individuals exhibiting a convex facial profile and a severely retrognathic mandible[9,12].

To date the above factors have been shown to be associated with alterations in craniofacial morphology. Any one or a number of these factors may affect the individual with varying degrees of expression and severity. The above factors are considered to be alterations in the local environment of the developing joint, and the expression or consequences have been demonstrated in previous studies. Disc displacement, another form of localized disturbance in the functional environment of the TMJ, has not been studied adequately to assess its association with altered craniofacial morphology. Schellhas et al[14] have suggested that MRI determined disc displacement is associated with alteration in facial morphology, but no quantitative measures of alteration in facial morphology were presented from the surgical sample investigated.

Disc displacement and clinically detectable joint sounds of the TMJ in the adolescent population are well documented[15-19], but to date the effects of disc displacement on adolescent facial morphology are unclear. It has not been possible to determine whether disc displacement leads to the development of malocclusion or vice versa. Katzberg *et al*[20] were able to show a localized association between disc displacement and degenerative joint disease in the TMJs of an adolescent sample. The authors[20] further reported decreased mandibular growth and associated facial changes in selected individuals from the sample. Associations between clinical findings and alteration in craniofacial pattern have been attempted in univariate assessments, but the findings have been contradictory and inconclusive[21,22].

Evaluation of the TMJs making use of both clinical information and history indicates that the prevalence of TMJ disorders in the adolescent population is as high or higher than that found in adults[15,18,23,24]. Investigation into an abnormal condyle-disc relationship making use of a history or clinical evaluation of joint sounds and TMJ pain may however be inadequate[25,26]. In addition, it has been shown that clinical evaluation overstates the true prevalence of the disorder when compared to magnetic resonance imaging (MRI) of the TMJ[27].

Magnetic resonance imaging is extremely sensitive for the identification of TMJ disc displacement[28,29], and for determining alteration in fluid distribution within joints[30,31]. In addition MRI is non-invasive, makes use of no radiation, no injection of contrast medium into the joint producing soft tissue distortion, and provides a direct image of the discal structures of the articulation.

Alterations in disc position evident on MRI affect the normal physiology, lubrication, nutrition and function of the joint[32-34]. This may be adequate to disturb the normal adaptive capacity of the condylar cartilage, resulting in a loss of equilibrium in the growing condyle. As shown previously[1,7,9,12,13], a decreased contribution of condylar cartilage to mandibular and facial development is associated with altered craniofacial morphology. It is possible that disc displacement may be associated with similar alterations in facial morphology.

This study tests the hypothesis that there is no difference in facial cephalometric measurements between adolescent individuals with and without MRI determined disc displacement affecting the temporomandibular joints.

### 7.2 Methods and Materials

Information was gathered on 194 subjects (75 males and 119 females) between the ages of 10 and 17 years, regardless of TMJ status and without previous or current orthodontic therapy. All subjects consented to radiographic and MRI evaluation. The group consisted of subjects with and without clinically detectable TMJ symptomology (capsular pain; joint sounds; masticatory muscle tenderness; limited mandibular range of motion; deviation on opening). No individuals with diagnosed juvenile rheumatoid arthritis affecting the TMJs were however included in the study.

Magnetic Resonance Imaging of the TMJs were performed without sedation using a 1.0 T magnet (Shimadzu Corporation 3, Tokoyo 101, Japan) and a unilateral 3 inch surface receiver coil. Axial scout images were obtained to identify the condyles. Bilateral closed-mouth sagittal sections were obtained perpendicular to the long axis of the condyle, and coronal images were obtained parallel to the condylar long axis. Closed mouth images were obtained making use of polyvinylsiloxane (President Jet-Bite, Coltene/ Whaledent Inc. Mahwah, NJ) centric occlusion bite registration. Bilateral open mouth sagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening. T1-weighted 500/20 (TR ms/ TE ms) pulse sequences were performed on all subjects using a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204.

Closed mouth lateral cephalometric radiographs were obtained for each subject, making use of the same polyvinylsiloxane centric occlusion bite registration. Open mouth, lateral cephalometric radiographs were exposed to accurately determine the shape of the condyle. All radiographs were acquired making use of a Siemens OP10 radiographic machine with each subject positioned in a cephalostat by means of ear-rods. Subjects were instructed to gaze directly ahead into the mirror image of their pupils and to place the teeth in maximum intercuspation with the bite registration interposed.

Lateral cephalometric radiographs were traced on acetate tracing film by a single investigator, and retraced approximately two weeks later. An accurate outline of the condylar head was obtained by superimposing the closed mouth tracing of the symphysis, the lower border of mandible, developing dental follicles and enamel organ where present, on the open mouth image. Linear and angular cephalometric measurements were chosen to represent the anterior and posterior vertical dimensions, as well as cranial base, mandibular and maxillary sagittal measurements. Linear and angular cephalometric variables are listed in Table 7.1 and 7.2 respectively, together with a description of the anatomic landmarks[35].

Landmarks were digitized using a Summasketch II digitizing tablet and a cross-hair cursor. Microsoft Visual Basic software served as a platform for a custom designed program to interpret the digitized data and record the angular and linear measurements. The magnitude of error associated with repeat digitization of the same point with replacement of the cursor between digitization was calculated to be 0.00 mm with a standard deviation of 0.11 mm.

| Name | Description |
|---|---|
| SN | Sella - Nasion |
| S-Ba | Sella - Basion |
| S-Co | Sella - Condylion |
| S-Ar | Sella - Articulare |
| S-Go | Sella - Gonion |
| SN-PNS | Posterior Nasal Spine perpendicular to Sella - Nasion plane |
| Ba-N | Basion - Nasion |
| N-ANS | Nasion - Anterior Nasal Spine |
| ANS-Me | Anterior Nasal Spine - Menton |
| N-Me | Nasion - Menton |
| 6/ANS-PNS | Maxillary mesiobuccal cusp tip perpendicular to palatal plane |
| Ptm-ANS | Pterygomaxillary fissure point inferior - Anterior Nasal Spine |
| Co-Go | Condylion - Gonion |
| Ar-Go | Articulare - Gonion |
| Co-Me | Condylion - Menton |
| Ar-Me | Articulare - Menton |
| Go-Me | Gonion - Menton |
| LI/Go-Me | Lower Incisor Tip perpendicular to Gonion - Menton plane |

Table 7.1: Linear Cephalometric Variables

| Name | Description |
|---|---|
| N-S-Ba | Nasion - Sella - Basion |
| SN/Ar-Go | Sella - Nasion/ Articulare - Gonion |
| FH/Ar-Go | Frankfort horizontal/ Articulare - Gonion |
| FH/Co-Or | Frankfort horizontal/ Condylion - Orbitale |
| BaN/Ptm-Gn | Basion - Nasion/ Pterygomaxillary point - Gnathion |
| UI-LI | Upper Incisor/ Lower Incisor |
| LI/Go-Me | Lower Incisor/ Gonion - Menton |
| UI/ANS-PNS | Upper Incisor/ Anterior Nasal Spine - Posterior Nasal Spine |
| Ar-Go-Me | Articulare - Gonion - Menton |
| SN/ANS-PNS | Sella - Nasion/ Anterior Nasal Spine - Posterior Nasal Spine |
| SN/Go-Me | Sella - Nasion/ Gonion - Menton |
| FH/Go-Me | Frankfort horizontal/ Gonion - Menton |
| ANS-PNS/Go-Me | Anterior Nasal Spine - Posterior Nasal Spine/ Gonion - Menton |

Table 7.2: Angular Cephalometric Variables

MR images produced for each slice of the joint were traced on acetate by a single observer in order to identify the osseous articular surfaces as well as the articular disc. Reference planes were transferred from corresponding lateral cephalometric tracings according to the previously described technique[36]. The addition of reference planes and in particular the establishment of the eminence reference plane facilitated the measurement of disc length, disc displacement and the calculation of a ratio of disc displacement/ disc length. These three variables were incorporated in a discriminant analysis for categorization of disc status[36].

Discriminant analysis was used to verify subjective classification of MRI determined disc position[36]. Subjective evaluation classified disc status into one of six categories. The categories of disc position were as follows (Figure 7.1):

1. *Normal disc position*

   In the closed mouth position the intermediate zone of the disc was interposed between the head of the condyle and the posterior slope of the articular eminence, with the anterior and posterior bands equally spaced on either side of the condylar load point in a bow tie appearance[37].

2. *Slight anterior displacement of the disc*

   The intermediate zone of the disc was slightly anteriorly displaced from between the osseous articular components. The head of the condyle apposed the posterior band of disc.

3. *Moderate anterior displacement of the disc*

   The intermediate zone of the disc was completely displaced from between osseous articular structures. The head of condyle was in contact with the junction between posterior band of the disc and the bilaminar zone.

4. *Full displacement of the articular disc*

   The entire articular disc was anteriorly displaced relative to the posterior slope of the articular eminence and head of the condyle. The bilaminar zone of the disc was interposed between the osseous articular structures and occupied the narrowest joint space. The disc reduced on mouth opening.

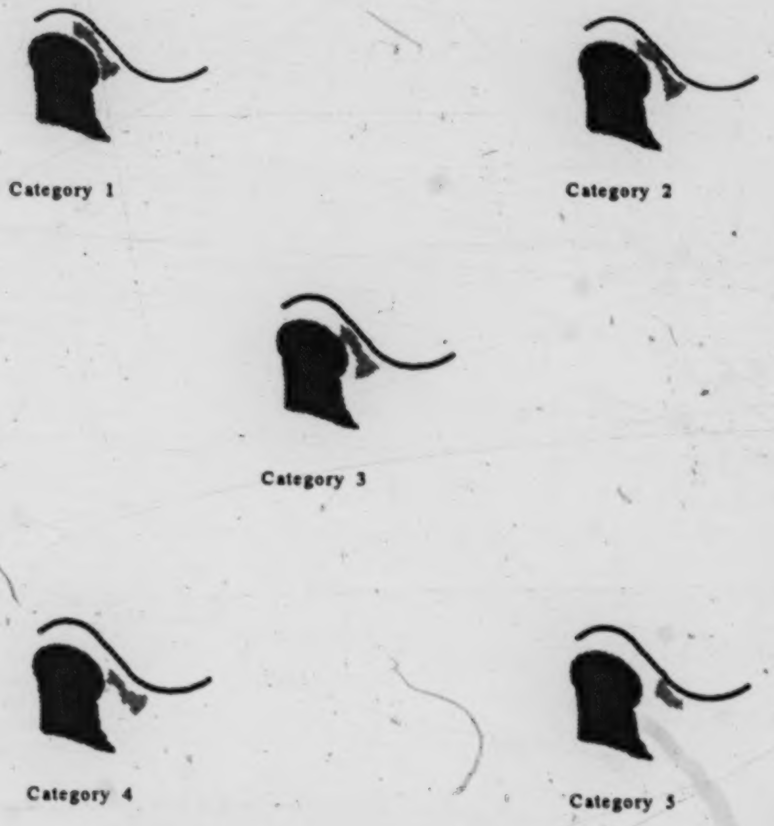
   (categories 1-4 all exhibited disc reduction on mouth opening)

5. *Full displacement of the articular disc without reduction on opening*

   Identical description to category 4, but without reduction of the disc on mouth opening.

6. *Non-categorizable disc position*

   MR images produced were of poor diagnostic quality, and could not be interpreted for disc position.



Category 1

Category 2

Category 3

Category 4

Category 5

Figure 7.1: Categories of Disc Status

On the basis of the discriminant analysis a categorical score was assigned to each temporomandibular joint slice produced by MRI. Any joint therefore had between 3 and 6 categorical scores assigned to it. Since this study was interested in determining the differences in facial cephalometric variables between individuals with normal TMJs compared to those with disc displacement, only joints that had slices consistently classified as categories 1, 4, or 5 were used. Making use of this data, two categories of interest were established:

- A joint was classified as "normal" only if all slices were categorized by discriminant analysis as category 1 (normal);

- Category 4 (total disc displacement with reduction) and category 5 (total disc displacement without reduction) were combined to form a single category denoted as "total disc displacement". All slices within a single joint had to be categorized as either category 4 or 5 to assign the joint to this category.

Once a single category was assigned to each joint, each subject was evaluated to determine whether the two categories of interest, namely, normal and total disc displacement, occurred unilaterally or bilaterally. Since this study was concerned with absolute differences in cephalometric variables obtained on lateral cephalometric radiographs it was considered prudent to compare only subjects with bilateral normal disc status to subjects with bilateral total disc displacement. Therefore subjects that scored normal in both joints were assigned to the normal group, while individuals that consistently scored totally displaced in both the left and right joints were assigned to the totally displaced group.

According to this classification only two males presented with total disc displacement in both the left and right temporomandibular joints, whereas twenty-three had bilateral normal disc position. In contrast, females presented more frequently with bilateral total disc displacement as interpreted from MRI discriminant analysis. Bilateral total disc displacement occurred in seventeen female adolescents imaged. A smaller number of females than males presented with bilateral normal disc position, with only seventeen falling into this category.

It was not possible to carry out any meaningful comparisons amongst the male sample, as only two presented with bilateral total disc displacement. It was also not possible to determine the onset of internal derangement or to establish the effect of duration of the disorder on cephalometric variables. This study therefore focused only on female subjects to determine whether cephalometric differences occurred between individuals with bilateral normal disc position compared to individuals with bilateral total disc displacement.

## 7.3 Error of Method

Intra-rater reliability in identification of cephalometric landmarks and measurement of cephalometric variables was tested by retracing ten radiographs on five separate occasions. Multivariate ANOVA procedure with patients and tracings as factors were utilized to generate an F- statistic and determine the coefficient of intra-rater reliability (Rel = 1-1/F) for thirty-one cephalometric variables[38]. F-statistic measures the significance of between tracing variability, so 1-1/F measures within tracing variability (repeat tracing variablity) relative to total variability.

All angular and linear cephalometric variables had a coefficient of intra-rater reliability (Rel = 1-1/F) between 0.97 and 1.00. This means that if total variability is measured as 1, and between tracing variability was calculated to be 0.97, the remaining variability (0.03) is due to tracing error or intra-rater error. This was considered to be negligible error and could be ignored.

In addition to performing an ANOVA, standard deviations for cephalometric variables were calculated over all tracings, as well as over all subjects. Means of standard deviations were calculated and ranged from 0.27 to 0.94 mm for linear variables, and 0.48 to 1.72 degrees for angular variables. For this study the acceptable Margin of Error was set at 1 mm for linear variables and 1 degree for angular variables. Variables with a computed margin of error greater than these cut-off points should be interpreted with caution.

Intra-rater reliability measurements of disc length and degree of disc displacement were previously established[36]. Coefficient of intra-rater reliability (Rel = 1-1/F) for disc length and disc displacement were computed to be 1.00 and 0.98 for disc displacement and disc length respectively.

## 7.4 Statistical Analysis

Differences in craniofacial cephalometric measurements between female adolescents classified as having normal articular disc position in the TMJs, and females with total disc displacement were evaluated making use of two-tailed t-tests for independent samples. In addition the independent t-test was used to determine if a difference in chronological age between the two groups contributed to the variability in cephalometric measurements between the two groups.

## 7.5 Results

Results of the independent t-test for differences in age, linear, and angular cephalometric variables between the two groups are presented in Table 7.3, 7.4 and 7.5 respectively.

The mean difference in chronological age between the two groups was computed to be 0.121 years. The mean age of adolescent females in the normal disc position group was 13.53 years compared to 13.65 years for the total disc displaced group. No statistically significant difference in chronological age was evident between the two groups.

| Variable | 2-tailed Significance | 95% C.I. for difference | Mean difference (years) |
|---|---|---|---|
| Age | 0.844 | -1.367, 1.125 | 0.121 |

*level of significance p-value = 0.05

Table 7.3: Independent t-test for Determination of Age Differences Between Two Groups.

The mean difference between the two groups for Sella - Gonion (S-Go) measurements was 5.57 mm. The totally displaced group had a statistically significantly smaller total posterior facial height (S-Go) compared to the normal group. Mean differences between the two groups for measurements of Condylion - Gonion (Co-Go), and Articulare - Gonion (Ar-Go) showed mean differences of 4.18 mm and 3.63 mm respectively. This indicates that much of the posterior facial height deficit in the totally displaced group was due to a smaller ramus height (Co-Go; Ar-Go). In addition, the mean difference between the groups for measurement of Sella - Articulare (S-Ar) showed a reduction for the totally displaced group, therefore also contributing to the shortened total posterior face height. A reduction in Sella - Basion (S-Ba) was recorded to be statistically significant, but the clinical significance of this is more difficult to determine and was of lesser magnitude (2.42 mm).

The contribution of the mandibular condyle to development of the posterior facial height seems to be reduced, if the measurement of Condylion - Gonion, or Articulare - Gonion is considered to represent the condylar contribution to posterior facial height. No direct measurement of glenoid fossa position was attempted, therefore the contribution of the cranial base to posterior facial height is not known. This study did however show a reduction in Sella - Articulare measurements in the totally displaced group compared to the normal group, indicating that the cranial component of the joint may also be affected in cases of disc displacement. In contrast, no statistically significant difference in measurement of posterior nasal spine perpendicular to Sella - Nasion (SN-PNS) was noticed between the two groups, nor was there a difference in the vertical position of the maxillary first molar relative to the palatal plane (6/ANS-PNS) between the two groups.

| Variable | 2-tailed Significance | 95% C.I. for difference | Mean difference (mm) | Error of Measurement |
|---|---|---|---|---|
| SN | 0.322 | -2.321, 0.785 | 0.768 | 0.33 |
| S-Ba | 0.050 * | 0.002, 4.832 | 2.417 | 0.65 |
| S-Co | 0.057 | -0.063, 4.012 | 1.975 | 0.64 |
| S-Ar | 0.007 * | 0.718, 4.098 | 2.408 | 0.44 |
| S-Go | 0.004 * | 1.961, 9.182 | 5.571 | 0.55 |
| SN-PNS | 0.224 | -0.819, 3.364 | 1.273 | 0.52 |
| Ba-N | 0.668 | -2.867, 4.412 | 0.773 | 0.44 |
| N-ANS | 0.039 * | -4.989, -0.139 | 2.564 | 0.47 |
| ANS-Me | 0.636 | -20948, 4.758 | 0.905 | 0.52 |
| N-Me | 0.629 | -5.544, 3.402 | 1.071 | 0.27 |
| 6/ANS-PNS | 0.343 | -0.898, 2.505 | 0.804 | 0.44 |
| Ptm-ANS | 0.958 | -2.101, 2.212 | 0.056 | 0.72 |
| Co-Go | 0.041 * | 0.151, 7.111 | 3.631 | 0.73 |
| Ar-Go | 0.021 * | 0.685, 7.683 | 4.184 | 0.64 |
| Co-Me | 0.127 | -0.984, 7.542 | 3.279 | 0.74 |
| Ar-Me | 0.051 | -0.013, 8.679 | 4.333 | 0.76 |
| Go-Me | 0.503 | -2.270, 4.533 | 1.131 | 0.94 |
| LI/Go-Me | 0.133 | -0.468, 3.394 | 1.463 | 0.45 |

*level of significance p-value = 0.05

Table 7.4: Independent t-test for Linear Cephalometric Variables.

Determination of differences in measurements of anterior vertical facial heights did not reveal many significant differences between the two groups. Total anterior facial height, represented by measurements of Nasion - Menton (N-Me) did not show statistically significant differences between the two groups. Measurements of lower anterior facial height (ANS-Me), also did not exhibit any statistically significant differences. The only statistically significant difference in anterior vertical facial height measurements occurred in upper anterior facial height (N-ANS), where the totally displaced group had increased height compared to the normal group. This would indicate that either Nasion is more superior in this group, or that the anterior nasal spine is more inferiorly located compared to the normal group. This finding seems to contradict the findings of Bjork[9] that no rotation of the maxilla takes place when condylar development is altered. Kjellberg *et al*[13] did however show clockwise rotation of the maxilla in subjects with TMJs affected by Juvenile Rheumatoid Arthritis.

| Variable | 2-tailed Significance | 95% C.I. for difference | Mean difference (degrees) | Error of Measurement |
|---|---|---|---|---|
| N-S-Ba | 0.323 | -5.165, 1.753 | 1.706 | 0.72 |
| SN/Ar-Go | 0.001* | -8.771, -2.295 | 5.533 | 0.48 |
| FH/Ar-Go | 0.044 * | -6.59, -0.092 | 3.341 | 0.58 |
| FH/Co-Or | 0.267 | -0.554, 1.933 | 0.689 | 0.54 |
| BaN/Ptm-Gn | 0.028 * | 0.409, 6.526 | 3.467 | 0.58 |
| UI/LI | 0.184 | -13.064, 2.615 | 5.224 | 1.72 |
| LI/Go-Me | 0.083 | -0.605, 9.529 | 4.462 | 1.19 |
| UI/ANS-PNS | 0.553 | -4.344, 7.973 | 1.815 | 1.35 |
| Ar-Go-Me | 0.803 | -4.184, 3.267 | 0.459 | 0.58 |
| SN/ANS-PNS | 0.003 * | -7.391, -1.608 | 4.500 | 0.66 |
| SN/Go-Me | 0.003 * | -9.807, -2.176 | 5.992 | 0.52 |
| FH/Go-Me | 0.076 | -8.022, 0.422 | 3.800 | 0.72 |
| ANS-PNS/Go-Me | 0.474 | -5.683, 2.699 | 1.492 | 0.73 |

*level of significance p-value = 0.05

Table 7.5: Independent t-test for Angular Cephalometric Variables.

Angular measurements appear to complement the linear measurements in describing the differences in craniofacial patterns between the two groups. Female adolescents with total disc displacement showed an increase in palatal plane relative to Sella - Nasion (SN/ANS-PNS), as well as an increase of mandibular plane to Sella - Nasion (SN/Go-Me) compared to the normal group. The angle formed between Basion - Nasion/ Pterygomaxillary fissure - Gnathion (BaN/Ptm-Gn) was statistically significantly smaller in the totally displaced group compared to the normal group ($3.47^0$). This indicates a posterior displacement of Gnathion relative to anterior structures in the face. Posterior rotation of the mandible may also be interpreted from the data which shows an increase in angle between Sella - Nasion and Articulare - Gonion (SN/Ar-Go), as well as an increase in the angle between Frankfort horizontal and Articulare - Gonion (FH/Ar-Go) in the totally displaced group. This data suggests a posterior rotation of the posterior border of the mandibular ramus relative to the cranial reference structures SN and FH in the totally displaced group.

Angular and linear measurements describing the position of both the anterior and posterior dentition could not be used to discriminate between the two groups. There was no compensatory increase in height of the anterior alveolar process with a reduction in posterior dental height as noted by Bjork[9]. No differences were evident between the two groups when measurement of mandibular corpus length (Co-Me; Ar-Me; Go-Me) were considered. Furthermore, no compensatory change in Gonial angle (Ar-Go-Me) was noticed as a result of disc displacement in the totally displaced group.

## 7.6 Discussion

Disc displacement affecting the TMJ may be seen as a localized disturbance in the functional environment of the temporomandibular joint. In the normal healthy joint the articular disc is interposed between the head of the condyle and posterior slope of the articular eminence during all functional movements[39]. The disc functions as a shock absorber and fills in the space between the incongruous osseous surfaces. It is also responsible for the distribution of synovial fluid across the joint surfaces which aids in lubrication, nutrition and oxygenation of the articular cartilages[40,41].

Loss of normal disc position compromises the load distribution of the joint, sets up areas of increased shear and compressive stress, reduces the lubrication of the joint surfaces, and ultimately results in tissue damage with infammation. Compromised nutrition, oxygenation and lubrication, superimposed on an inflammatory zone results in biochemical alterations which with the progress of time are expressed as cellular changes and morphological alterations in tissues[32,42].

In the growing individual the proliferative layer of cartilage cells beneath the fibrous articular layer may be affected by lack of nutrition and lubrication resulting in cell damage and death. A loss of cellular components able to synthesize matrix and proteoglycans further destabilizes the already compromised region. The result is a reduction in the normal adaptive capacity of the cellular region to development, and possibly also regressive remodelling with actual loss of previously formed structural condylar tissue[32]. Ultimately this is seen as a reduction in condylar height, ramus vertical development, and a reduction in posterior facial height associated with total disc displacement.

Independent sample t-test results show that there are differences in cephalometric measurements of craniofacial morphology between individuals with normal disc position compared to individuals with total disc displacement. There was however no statistically significant difference in chronological age between the two groups investigated.

Female adolescents categorized by discriminant analysis of MR images as having bilateral total articular disc displacement of the TMJs presented with craniofacial features that could be summarized as a deficiency in posterior vertical facial morphology, with a slight excess in the anterior facial region. All measurements of posterior vertical facial height were reduced in the totally disc displaced group.

The findings of this study indicate that differences in facial morphology do occur between individuals with total disc displacement in the TMJs compared to individuals with normal disc position. The changes in facial morphology are similar to those described by Bjork[9] for individuals affected by bilateral condylar hypoplasia, or due to the effects of juvenile rheumatoid arthritis[13]. The effects are however of a much lesser magnitude, and do not present as severe facial deformities. These initial facial changes may be overlooked by the clinician unfamiliar with facial changes associated with disc displacement.

A line diagram representing the mean linear and angular measurements for the two groups with artistic soft tissue adapted is presented in Figure 7.2. By superimposing line diagrams for the normal and totally displaced groups on Sella - Nasion line at Nasion, the relative contribution of each of the cephalometric measurements to the face can be evaluated. The line diagram therefore serves the purpose of illustrating the compound effects of altered craniofacial morphology.

This study was designed to determine if differences in craniofacial morphology occurred between individuals with bilateral normal TMJ disc position compared to individuals with bilateral TMJ total disc displacement. Individuals with unilateral disc displacement may show similar features, but only unilaterally, thus contributing to the appearance of facial asymmetry.

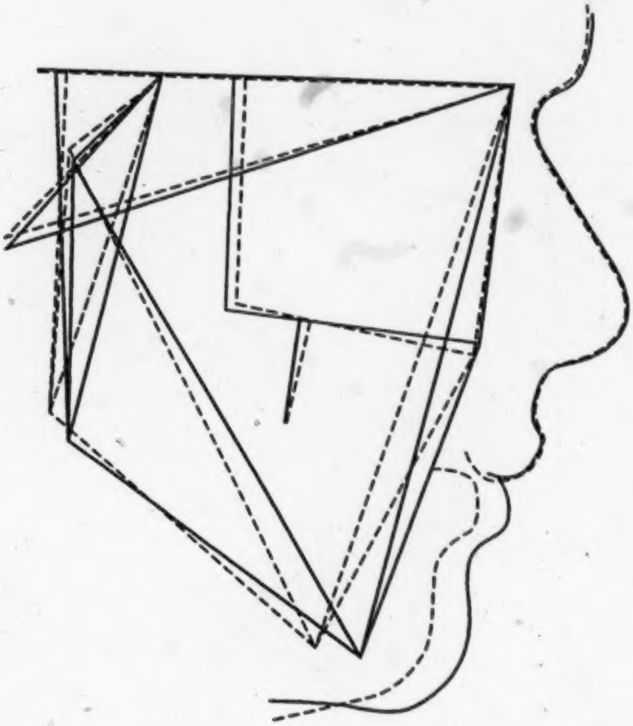


Figure 7.2: Line Diagram for Total Disc Displacement and Normal Disc Position Groups
*** Dashed line denotes Total Disc Displacement Group, Solid line denotes Normal Disc Position Group. Superimposition on SN at S.**

To date the effects of partial disc displacement on the growing individuals are not known. No studies have examined the relationship between the articular components of the joint in sufficient detail to explain the effect of partial displacement on function, nor the effects of partial displacement of the disc on condylar development in adolescent individuals. It remains to be seen whether one pattern of partial disc displacement is more prone to progression to total disc displacement without reduction, and is more strongly associated with alteration in craniofacial morphology than another.

Although associations between TMJ disc displacement and facial pattern have been demonstrated, a cause-effect relationship cannot be assumed. Disc displacement may affect facial growth, or disc displacement my occur as a consequence of biomechanics associated with an altered facial pattern. It is also possible that both disc displacement and facial pattern are the result of another influencing factor not yet identified. In addition, some of the difference in mandibular position noted between the two groups could be as a result of condylar repositioning which may accompany disc displacement. The magnitude of the differences in facial dimensions between the two groups, however, seem too large to be accounted for by the presence or absence of a 1.5 mm thick disc either interposed or displaced between the osseous articular surfaces. Longitudinal studies may aid in identification of causative and associated factors.

The significance of these findings have direct application in the clinical setting. Due to public awareness and education, individuals with severe skeletal and dental malocclusions will present for correction of these malocclusions. The identification of adolescent individuals with reduced posterior facial height, an increased mandibular plane angle and factors indicating posterior rotation of the mandible should alert the practitioner that the patient may not respond to conventional orthodontic therapy if growth modification is desired. In these instances the condylar contribution to mandibular development may be altered. These individuals may present with no distinct clinical signs and symptoms during the adolescent period but may develop orofacial pain later in life once the adaptive capacity of the proliferative tissues has reduced and further condylar remodeling occurs.

## 7.7 Conclusions

Independent sample t-test indicate that statistically significant differences in measurements of cephalometric variables occur between female adolescents with normal disc position compared to individuals with total disc displacement as determined by discriminant analysis of MRI findings of the TMJ.

The craniofacial pattern in individuals with total bilateral disc displacement is characterized by a reduction in posterior vertical facial height without a significant increase in anterior vertical facial height. The palatal plane and mandibular plane show a more marked convergence toward the posterior region of the face in individuals with total disc displacement compared to the group with bilateral normal disc position. There were however no anterior or posterior vertical dentoalveolar compensatory tooth movements in the totally disc displaced group compared to the normal group. This is in contrast to the findings of Bjork[9] in subjects with condylar hypoplasia.

Statistically significant differences between the two groups occurred for both angular and linear cephalometric variables. These differences were of sufficient magnitude to be considered clinically significant in the growing individual. Hence, based on the findings in this study it cannot be stated that abnormal disc position in adolescents is within the range of normal anatomic variation.

## 7.8 References

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# CHAPTER 8

## Female Adolescent Facial Pattern associated with TMJ Disc Displacement and Reduction in Disc Length

### 8.1 Introduction

Temporomandibular joint disc displacement may be considered as a localized alteration in the functional environment of the joint. During normal function the intermediate zone of the disc is interposed between the head of the mandibular condyle and the posterior slope of the articular eminence[1-3]. In this position the disc is capable of protecting the articular surfaces from excessive masticatory forces[4] and provides the osseous articular surfaces with synovial fluid which aids in lubrication, oxygenation, hydration and nutrition of the joint[5]. Since the articular surfaces are devoid of direct vascular blood supply, the only nutrition these surfaces receive is via the synovial fluid[6]. Displacement of the disc results in the approximation of incongruous osseous surfaces, excessive point application of forces, tissue breakdown, and a loss of normal lubrication and nutrition provided by the pumping action of the disc during condylar loading[7].

In the growing individual where proliferating condylar cartilage underlies the fibrous articular tissue, loss of lubrication and nutrition as a result of disturbed disc function may reduce the proliferative capacity of this tissue. A loss of nutrition, oxygenation and hydration as a result of disc displacement, superimposed on the effects of increased point loading on the articular surfaces may result in disruption or breakdown of the proliferative cellular layers. Once proliferative cells are disturbed, there is a reduction in the formation of collagen matrix and proteoglycans which contribute to the continual tunover and growth of condylar tissue.

Whether the localized alteration in cartilage maintenance and production has an effect on condylar and ramal development is however not known. The extent to which disc displacement and disc deformation affect the cartilaginous contribution to ramal development also remains to be tested. If the disruption is extensive, would the result be a decreased vertical development in ramus height and altered mandibular morphology? Would other adaptive sutural systems of the craniofacial region be affected?

This study was designed to determine whether an association exists between disc displacement and disc deformation affecting the TMJs, and craniofacial morphology in a female adolescent sample. If these associations can be made, then research into mechanisms involved in the process may be initiated to determine if disc displacement is an initiating factor or a consequence of biomechanics associated with an altered facial pattern.

### 8.2 Methods and Materials

Craniofacial lateral cephalometric radiographs and magnetic resonance images (MRI) of the TMJs were obtained for 119 females between the ages of 10 - 17 years. Subjects were recruited from private orthodontic practices and the graduate orthodontic program at the University of Alberta, prior to undergoing orthodontic treatment and regardless of TMJ status. The group consisted of subjects with and without clinically detectable TMJ signs and symptoms (capsular pain; joint sounds; masticatory muscle tenderness; limited mandibular range of motion; deviation on opening). None of the individuals examined were previously diagnosed as having juvenile rheumatoid arthritis. All individuals consented to inclusion in the study which had previously been approved by the Joint Dentistry/ Pharmacy Human Ethics Committee.

Previously a study was conducted on females from the same sample who exhibited either bilateral normal disc position or bilateral total disc displacement. The study considered 34 females with extremes in MRI disc status[8]. This investigation however considers all female adolescent subjects included in the original sample, exhibiting a full spectrum of disc position from normal to totally displaced discs. Of the original 119 female adolescent subjects investigated 9 were excluded from further analysis due to poor cephalometric quality or motion artifacts during MRI investigation of the TMJs.

Magnetic Resonance Imaging (MRI) of the TMJs was performed without sedation using a 1.0 T magnet (Shimadzu Corporation 3, Tokyo, Japan) and a unilateral 3 inch surface receiver coil. Axial scout images were obtained to identify the condyles. Bilateral closed-mouth sagittal sections were obtained perpendicular to the long axis of the condyle, and coronal images were obtained parallel to the condylar long axis. Closed mouth images were obtained making use of polyvinylsiloxane (President Jet-Bite, Coltene/ Whaledent Inc. Mahwah, NJ, USA) centric occlusion bite registration. Bilateral open mouth sagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening. T1-weighted 500/20 (TR ms/ TE ms) pulse sequences were performed on all subjects using a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204.

Closed mouth lateral cephalometric radiographs were obtained for each subject, making use of the same polyvinylsiloxane centric occlusion bite registration. Open mouth, lateral cephalometric radiographs were exposed to accurately determine the shape of the head of the condyle. All radiographs were acquired making use of a Siemens OP10 radiographic machine with each subject uniformly positioned in a cephalostat by means of ear-rods.

Lateral cephalometric radiographs were traced on acetate tracing film by a single investigator, and retraced approximately two weeks later. An accurate outline of the condylar head was obtained by superimposing the closed mouth tracing of the symphysis, the lower border of mandible, developing dental follicles and enamel organ where present, on the open mouth image. Linear and angular cephalometric measurements were chosen to represent the anterior and posterior vertical dimensions, as well as cranial base, mandibular and maxillary sagittal measurements. Angular and linear cephalometric variables are listed in Table 8.1 and 8.2 respectively, together with a description of the anatomic landmarks[9].

Traced cephalometric landmarks were digitized using a Summasketch II digitizing tablet and a cross-hair cursor. Microsoft Visual Basic software served as a platform for a custom designed program to interpret the digitized data and record the angular and linear measurements. The magnitude of error associated with repeat digitization of the same point with replacement of the cursor between digitization was calculated to be 0.00 mm with a standard deviation of 0.11 mm.

| **Name** | **Description** |
|---|---|
| N-S-Ba | Nasion - Sella - Basion |
| SN/Ar-Go | Sella - Nasion/ Articulare - Gonion |
| FH/Ar-Go | Frankfort horizontal/ Articulare - Gonion |
| FH/Co-Or | Frankfort horizontal/ Condylion - Orbitale |
| BaN/Ptm-Gn | Basion - Nasion/ Pterygomaxillary point - Gnathion |
| UI-LI | Upper Incisor/ Lower Incisor |
| LI/Go-Me | Lower Incisor/ Gonion - Menton |
| UI/ANS-PNS | Upper Incisor/ Anterior Nasal Spine - Posterior Nasal Spine |
| Ar-Go-Me | Articulare - Gonion - Menton |
| SN/ANS-PNS | Sella - Nasion/ Anterior Nasal Spine - Posterior Nasal Spine |
| SN/Go-Me | Sella - Nasion/ Gonion - Menton |
| FH/Go-Me | Frankfort horizontal/ Gonion - Menton |
| ANS-PNS/Go-Me | Anterior Nasal Spine - Posterior Nasal Spine/ Gonion - Menton |

Table 8.1: Angular Cephalometric Variables

In addition to tracing the cephalometric radiographs, the investigator examined the sagittal MR images of the TMJ which were produced from 3 mm thick volume slices of the joint, producing 4 to 6 images per joint. All sagittal MRI slices were traced to determine the relationship between the osseous articular structures and the articular disc. Reference planes were transferred from corresponding lateral cephalometric tracings according to the previously described technique[10].

| Name | Description |
|---|---|
| SN | Sella - Nasion |
| S-Ba | Sella - Basion |
| S-Co | Sella - Condylion |
| S-Ar | Sella - Articulare |
| S-Go | Sella - Gonion |
| SN-PNS | Posterior Nasal Spine perpendicular to Sella - Nasion plane |
| Ba-N | Basion - Nasion |
| N-ANS | Nasion - Anterior Nasal Spine |
| ANS-Me | Anterior Nasal Spine - Menton |
| N-Me | Nasion - Menton |
| 6/ANS-PNS | Maxillary mesiobuccal cusp tip perpendicular to palatal plane |
| Ptm-ANS | Pterygomaxillary fissure point - Anterior Nasal Spine |
| Co-Go | Condylion - Gonion |
| Ar-Go | Articulare - Gonion |
| Co-Me | Condylion - Menton |
| Ar-Me | Articulare - Menton |
| Go-Me | Gonion - Menton |
| LI/Go-Me | Lower Incisor Tip perpendicular to Gonion - Menton plane |

Table 8.2: Linear Cephalometric Variables

The addition of reference planes and in particular the establishment of the eminence reference plane facilitated the measurement of disc length and disc displacement on each sagittal MRI slice of each joint.

### 8.3 Error of Method

Determination of intra-rater reliability in measurement of disc length and degree of disc displacement was determined by selecting ten MRI's representative of normal disc position, and ten representative of disc displacement. These twenty MRI's were retraced five times each on consecutive days to determine the error of measurement. Coefficient of intra-rater reliability (Rel = 1-1/F)[11] for disc length and disc displacement were computed to be 1.00 and 0.98 for disc displacement and disc length respectively[10].

Intra-rater reliability in identification of cephalometric landmarks and measurement of cephalometric variables was tested by retracing ten radiographs on five separate occasions[8]. Coefficients of intra-rater reliability (Rel = 1-1/F) for thirty-one cephalometric variables were determined[11]. All cephalometric variables had a coefficient of intra-rater reliability (Rel = 1-1/F) between 0.97 and 1.00. This was considered to be negligible error and could be ignored. Repeat measurements of cephalometric variables were therefore averaged to produce a single average cephalometric variable which was utilized in further analyses.

In addition to performing an ANOVA, standard deviations for cephalometric variables were calculated over all tracings, as well as over all subjects. Three cephalometric variables had error of measurement greater than 1 degree, (UI/LI $1.72^0$; LI/Go-Me $1.19^0$; UI/ANS-PNS $1.35^0$). These variables were considered in the study but results should be interpreted with caution.

## 8.4 Data Analysis

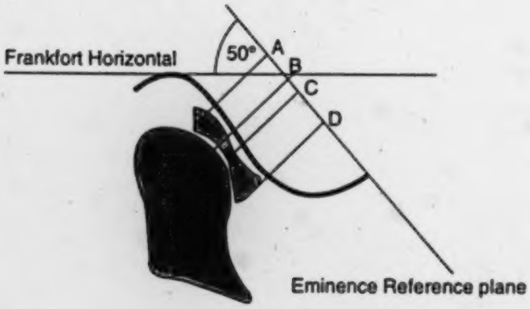
Thirteen angular and 18 linear cephalometric measurements were recorded for each subject included in the study. In addition, linear measurements of disc displacement (DD) and disc length (DL) were recorded on sagittal MRI slices of the TMJ. A multiple regression model was chosen as the statistical model most appropriate to interpret the associations between TMJ disc information and craniofacial cephalometric measurements.

The independent variables were the angular and linear cephalometric variables, while the dependent variables were the TMJ sagittal slice information for DD and DL. Most statistical packages can however not accommodate more than one dependent variable, therefore variable reduction techniques were used, namely Principal component analysis (SPSS for Windows, SPSS Inc. Chicago, IL), to provide a single dependent variable for each subject.

### 8.4.1 Dependent Variable

Linear measurements of DD and DL were measured for each sagittal MRI slice of each joint making use of the previously described technique for quantification of disc status[10]. Disc displacement (DD) was measured in millimetres as the total linear displacement of the discal midpoint from the condylar load point along the Eminence reference plane, while DL was measured as the total length of the disc along the Eminence reference plane from the posterior to the anterior band of the disc[10] (Figure 8.1).

To reduce the number of dependent variables, a Principal component analysis was employed which assigned a single weighted score for all DD measurements and for all DL measurements for each joint. At this stage it must be assumed that disc displacement is associated with alteration in facial morphology and that varying degrees of disc displacement are associated with varying degrees of facial alteration. It is also assumed that unilateral disc displacement is less severe than bilateral disc displacement and that the effect of disc displacement in either TM joint are additive. These assumptions allow a single additive score of DD to be assigned to each subject from which measurements of DD from the right and left joints were made.



**A** : Posterior band of disc **B** : Condylar load point **C** : Discal midpoint **D** : Anterior band of disc

Figure 8.1: Intra-articular Reference Points Relative to Eminence Reference Plane

Previously a negative relationship between DD and DL was shown[10]. This means that as disc displacement progresses in magnitude, an associated decrease in disc length occurs. In order to reduce the variables of DD and DL to a single variable it was considered prudent to allow the variables to proceed in the same relative direction. Therefore measurements of DL were subtracted from what was considered to be normal disc length (10.00 mm) to produce a reciprocal DL measurement[10].

Example: If disc length was measured to be 7.37 mm, then reciprocal disc length measurement was: 10 - 7.37 = 2.63 mm

Principal component factor analysis was employed to assign a single weighted score for all reciprocal DL measurements for each joint. A single additive score for reciprocal DL was calculated for each subject from measurements of the right and left joints as for DD measurements. Principal component factor analyses were once again employed on the DD

DD measure and reciprocal DL measure for each subject to produce a single dependent TMJ variable for the multiple regression analysis. The new dependent variable was a single measure of internal derangement for both TMJs per subject.

### 8.4.2 Independent Variables

Superimposition of right and left paired structures on two-dimensional lateral cephalometric radiographs limited side specific interpretation and measurement of cephalometric variables. Therefore a single averaged measurement was used to represent bilateral structures identified on lateral cephalometric films.

Cephalometric measurements are used to study the relative dimensions of facial components. The increase in absolute dimension of any facial measurement is however not linear. Some facial regions show early increases in dimension which then plateau off as growth declines. These are generally the dentoalveolar growth regions. Other skeletal components show increased dimensions during the pubertal growth spurt[9]. Subjecting these non-linear data to linear regression models to determine linear relationships between dependent and independent variables is therefore problematic.

Polynomial regression techniques are methods available to improve the fit of data to multiple regression models when second order curves exist as described above[12]. Quadratics of independent variables, variable squared ($V^2$); variable cubed ($V^3$), may be computed and included as independent variables in the regression model. In this study a quadratic variable ($\text{variable}^2$) was included for all 31 independent variables, while $\text{age}^2$ and $\text{age}^3$ were included as quadratic and cubic variables for the age of each individual.

### 8.4.3 Multiple Regression Model

A single dependent variable was made available for each subject included in the study, using the Principal component factor analysis previously described. In addition, 65 independent variables were available after quadratic variables (variable squared) were included with the original variables obtained in the study. A multiple regression model was employed to determine the association between the dependent and independent variables. The initial model included age and quadratic age variables as variables included in the regression equation.

The inclusion of age as a variable in the regression model is not helpful, as we already know that age influences the relative magnitude of the variables included in the model. It was therefore considered beneficial to control for age by removing the effect of age from all variables. This was done by first running multiple regression equations for each cephalometric and MRI variable with age, age$^2$ and age$^3$ as the independent variables, and the variable of interest as the dependent variable.

Example: $Y_1 = a + b_1X_1 + b_2X_2 + b_3X_3 + e$

where $Y_1$ is any variable (cephalometric or MRI)

$X_1$ = age; $X_2$ = age$^2$; $X_3$ = age$^3$

From each regression equation a constant (Y intercept) for age, age$^2$ and age$^3$ regressed against the dependent variable is produced. Residuals from the regression equation for each subject were also computed. The residual in the regression equation is the numerical component of the dependent variable which is unexplained by the independent variables, age, age$^2$ and age$^3$. If the residual is large, then age variables do not explain the behaviour of the dependent variable, and vice versa.

A new variable was now computed for each of the previous variables, either actual measurement variable or formed quadratic variable. The new variable score for each subject was formed by adding the residual value created for each subject to the constant produced for the particular variable when regressed against age, age$^2$ and age$^3$. In this way a new dependent variable for MRI TMJ quantitative score was developed, and 62 new independent cephalometric variables were created, all free of the effect of age.

Multiple regression models which could explain the variability in the dependent variable were sought by making use of cephalometric variables. Cephalometric variables were divided into five groups and five different regression analyses were performed to determine associations between the independent variables and the dependent variable in the following facial regions of interest (Table 8.3):

| Facial Region | Number of cephalometric variables entered |
|---|---|
| Cranial base | 14 |
| Maxilla | 14 |
| Mandible | 16 |
| Mandibular position | 10 |
| Dentition | 10 |

Table 8.3: Number of Independent Variables Included in each Regression Equation

Multiple regression models were employed with forced entry of independent variables. Independent variables which did not contribute significantly to explaining the variability in the dependent variable were removed from each model in a sequential stepwise manner until only significant independent variables remained in the model. These models are analagous to a Backward regression model with the exception that all insignificant variables are removed from the models prior to determining the complete regression equations[12]. In other words, in each of the five models all independent variables which contribute to explaining the variability in the dependent variable are included in each of the models. This method was chosen in preference to the Stepwise regression model which determines the simplest model with the fewest independent variables to be included in the equation. The Stepwise model provides only a model, but does not provide all cephalometric variables which contribute to explaining variability in the dependent variable. This study however wishes to determine which variables contribute significantly to an association with the dependent variable.

## 8.5 Results

Results of the Multiple regression equations making use of the procedures described above are included in Table 8.4.

The TMJ dependent variable in the multiple regression equation represents a score which quantifies both disc displacement and the reciprocal of disc length. An increase in this score should be interpreted as an increase in disc displacement with an associated reduction in disc length. For descriptive purposes this is described as an increase in internal derangement of the TMJ. A positive association between the dependent TMJ variable (internal derangement), and the angular and linear cephalometric measurements should be interpreted as an increase in the cephalometric dimension as the degree of internal derangement increases, and vice versa.

Variables may have been excluded from a regression equation in a particular facial region if the variable was highly correlated with other variables already in the equation. To determine if variables in the equation were highly correlated with variables excluded from the equation, Pearson correlation coefficients were computed. Variables which showed a high correlation with variables already in the regression equation are discussed in the relevant sections studied and presented in Table 8.5.

| Facial Region | Independent Variable | Significance | Correlation Coefficient | Adjusted R-squared |
|---|---|---|---|---|
| **Cranial Base** | SN | 0.025 | -0.051 | 0.107 |
| | N-S-Ba* | 0.049 | -0.019 | |
| | FH/Co-Or | 0.022 | -0.230 | |
| | Ba-N | 0.002 | -0.219 | |
| **Maxilla** | SN/ANS-PNS | 0.000 | +0.215 | 0.238 |
| | 6/ANS-PNS | 0.009 | -0.106 | |
| | ANS-PNS/Go-Me | 0.000 | +0.286 | |
| **Mandible** | Co-Go | 0.002 | -0.258 | 0.322 |
| | Co-Go* | 0.014 | -0.244 | |
| | Co-Me | 0.005 | -0.221 | |
| | Ar-Me | 0.006 | -0.317 | |
| | Ar-Me* | 0.007 | -0.315 | |
| | Go-Me | 0.000 | -0.196 | |
| | Go-Me* | 0.002 | -0.186 | |
| | S-Go | 0.001 | -0.343 | |
| | Ar-Go-Me | 0.001 | +0.138 | |
| | N-Me | 0.047 | +0.138 | |
| **Mand. Position** | SN/Go-Me | 0.000 | +0.450 | 0.195 |
| **Dentition** | 6/ANS-PNS | 0.041 | -0.106 | 0.140 |
| | UI/LI | 0.000 | -0.046 | |
| | LI/Go-Me (angle) | 0.000 | -0.205 | |
| | UI/ANS-PNS | 0.023 | +0.002 | |
| | UI/ANS-PNS* | 0.036 | +0.010 | |

* Superscript 2 denotes quadratic variable

Table 8.4: Variables Included in Multiple Regression Equation

| Facial Region | Variable in Equation | Correlated Variable | Correlation |
|---|---|---|---|
| **Mandible** | **Ar-Go** | **Co-Me** | +0.874 |
|  | **N-Me** | **ANS-Me** | +0.902 |
| **Mandibular Position** | **SN/Go-Me** | **FH/Go-Me** | +0.907 |
|  | **SN/Go-Me*** | **BaN/Ptm-Gn** | -0.840 |

Table 8.5: Independent Variables Correlated with Independent Variables in Equation

## 8.6 Discussion

Angular and linear cephalometric variables were selected to represent vertical and anteroposterior dimensions in each of the five craniofacial regions. Variables which were included in a multiple regression equation for a particular facial region, contributed to describing the variability noted in measurements of internal derangement. Where a quadratic variable was included in the regression equation, the slope of the quadratic was matched to the slope of the original independent data to determine which region of the data could be interpreted by inclusion of the quadratic term. The region of data corresponding to the slope of the quadratic term could then be interpreted to be linearly associated with the dependent variable.

### Cranial Base

Four cephalometric variables contributed to explaining the variability in measurement of MRI determined internal derangement. A negative association between all four cephalometric variables included in the regression equation and internal derangement was noted. This implies an overall reduction in size of the anterior cranial base (SN), and posterior cranial base regions (Ba-N) in association with increased measures of internal derangement. In addition the cranial base flexure (N-S-Ba) becomes more acute, and the glenoid fossa and condyle are positioned more superiorly relative to Frankfort Horizontal within the posterior cranial base (FH/Co-Or).

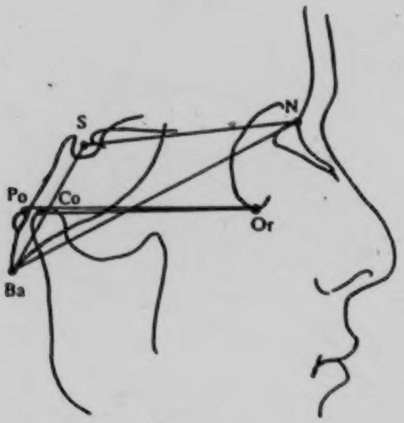


Figure 8.2: Cranial Base Variables entered into the Multiple Regression Equation

Measurements of FH/Co-Or showed a negative association with increased degrees of internal derangement, but direct vertical measurements of S-Co and S-Ar were not included in the regression equation. Neither did a strong correlation exist between these variables left out of the equation and FH/Co-Or. Possibly the increased flexure of the cranial base maintained the position of Sella relative to the head of the condyle, and no reduction in height was measured here. Alteration in glenoid fossa position in individuals with various facial types has been observed previously[13,14]. It is possible that internal derangement is associated with a reduced vertical development of the secondary cartilage which contributes to growth of the articular eminence and development of the fossa, thus contributing to the relative lack of vertical development in this region. The adjusted R-squared for this facial region was however low at 0.107, explaining only approximately 11% of the variability associated with measures of internal derangement.

**Maxilla**

Cephalometric variables used to describe the dimensions and relative position of the maxilla within the face contributed to explaining the variability in internal derangement. Three cephalometric variables were included in the regression equation and explained 23.8% of the variability in the dependent variable.

The inclination of the palatal plane relative to Sella - Nasion, and its inclination relative to the mandibular plane (Go-Me) were found to be positively associated with increasing measures of internal derangement. These measures, SN/ANS-PNS and ANS-PNS/Go-Me, increased with increasing measures of internal derangement. The height of the maxillary first molar relative to the palatal plane (6/ANS-PNS) showed a negative association with the dependent variable, therefore decreasing as the degree of internal derangement increased.

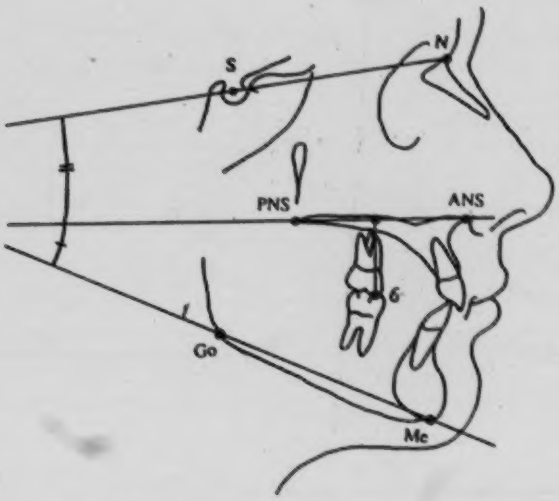


Figure 8.3: Maxillary Variables entered into the Multiple Regression Equation

Anterior (N-ANS) and posterior (SN/ANS-PNS) vertical cephalometric variables describing skeletal dimensions were not included in the regression equation. No linear association between internal derangement and vertical maxillary position was shown. The cephalometric measure of sagittal maxillary length (Ptm-ANS) was also not included in the regression equation.

**Mandible**

Mandibular cephalometric variables were well represented in the regression equation and contributed up to 32.2% in explaining the variability in TMJ internal derangement. Cephalometric variables showing a negative association with increasing measures of internal derangement identified a reduction in sagittal length of the mandibular corpus (Ar-Me, Go-Me, Co-Me), a reduction in vertical ramus height (Co-Go) and a reduction in total posterior facial height (S-Go).

A positive association between internal derangement and Ar-Go-Me indicates an increase in the gonial angle associated with increased measures of internal derangement. Similarly, a positive association between the dependent variable and N-Me indicates that the total anterior facial height increases with increasing measures of internal derangement.

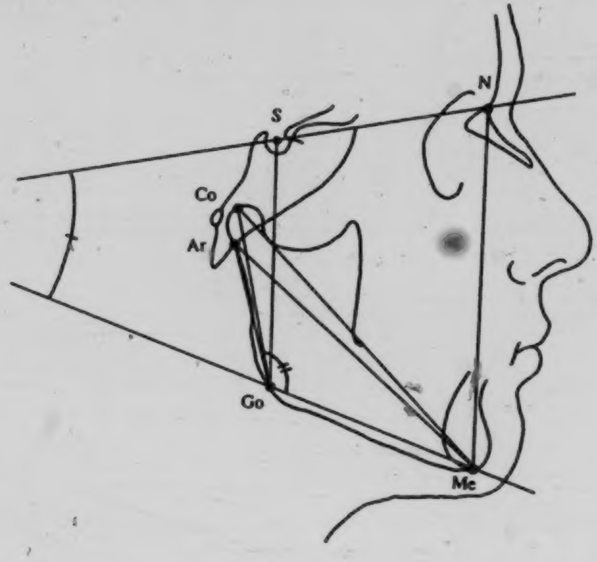


Figure 8.4: Mandibular Variables entered into the Multiple Regression Equation

In summary, the mandible shows a reduction in posterior vertical dimensions, a reduction in sagittal dimensions, an increased flexure between the ramus and corpus as interpreted by increased Ar-Go-Me angular measurement, and an increase in total anterior facial height associated with increased measures of internal derangement in this adolescent female sample. Similar alterations in mandibular morphology have been described in individuals with radiographic alteration in condylar morphology[15], and in individuals with juvenile rheumatoid arthritis[16,17] of the TMJ. Reduced sagittal dimensions of the mandible were also shown in an adult sample with MRI determined disc displacement[18].

### Mandibular Position

Cephalometric variables entered into this model attempted to determine the position of the mandible in space by locating the most anterior point on the bony symphysis (Gn) relative to the cranial base (Ba-N). The mandibular plane relative to SN and Frankfort Horizontal was also entered, as well as the inclination of the posterior border of the ramus relative to the above mentioned cranial reference planes.

Only one cephalometric variable remained in the regression equation and contributed to explaining variability in measurements of internal derangement of the TMJ. Mandibular plane (Go-Me) relative to SN was included in the regression equation, and the adjusted R-squared value for this equation was 0.195. There was a positive association between SN/Go-Me and the dependent variable, indicating an increase in the mandibular plane angle with increased severity of internal derangement. In addition, high correlations were noted between measures of SN/Go-Me and FH/Go-Me (+0.907), and between SN/Go-Me and BaN/Ptm-Gn (-0.840), emphasizing the increased inclination of the mandibular plane to the cranial reference planes.

### Dentition

Variables entered into this regression equation produced an adjusted R-squared of 0.14. Once again the vertical position of the maxillary first molar (6/ANS-PNS) was included in the regression equation and showed a negative association with the dependent variable. The angulation of the lower incisor relative to the mandibular plane showed a negative association with the dependent variable, as did the interincisal angle (UI/LI). The inclination of the maxillary incisor relative to the palatal plane was included in the regression equation and showed a positive association with the dependent variable, but the association was extremely weak.

The significance of variables defining the position of the dentition should be interpreted with caution, as these variables showed intra-rater error of measurement greater than one degree. These variables showed great variability in measurement determination and reproducibility of these variables was low.

It has therefore been shown that associations do occur between internal derangement of the TMJ and craniofacial morphology. The clinical significance and magnitude of these associations are not that well demonstrated making use of multivariate statistical techniques. They do however tend to indicate linear relationships between increasing measures of internal derangement and craniofacial cephalometric patterns. The adjusted R squared values for each region studied may be considered to be rather low, but this may have occurred due to the divisions imposed in the study. In addition, when it is considered that there are many other factors (environmental, hormonal, genetic and inflammatory), that have an influence on facial morphology, it is not surprising that these value are no higher.

This study was able to identify associations between MRI determined internal derangement and craniofacial morphology in an adolescent female sample. Many of these individuals had not completed growth and were still undergoing active development. This study was able to show associations at a single point in time, but it is not known to what extent these individuals will be affected once growth is completed. It is however evident that the facial morphology is affected, indicating that with time the discrepancy between various facial components may increase. This is important when a decision regarding treatment has to be made. These individuals may not respond to normal growth modification and treatment if interceptive orthodontics is initiated. They may however benefit from treatment at a later stage when growth is completed and the full extent of the discrepancy between facial components can be determined.

Growth modification making use of functional appliances supposes that the temporomandibular joint is intact and functional. In Class II patients the mandible is advanced in an attempt to stimulate condylar proliferation, guide tooth eruption and effect fossa remodeling[19]. The exact extent and mechanisms of change in the relationship of the mandible to the maxilla is highly controversial, but it has been claimed that functional appliances can change the direction, or stimulate mandibular growth. Anterior positioning of the condyle relative to the posterior slope of the articular eminence in a joint with disc displacement may contribute to further soft tissue damage and inflammation if the disc is not recaptured with the mandibular advancement. This procedure could interfere with the adaptive capacity of the retrodiscal tissues and result in condylar remodeling and a loss of condylar vertical height.

Adolescents are extremely adaptive, undergoing change in size and shape as they grow. In the facial region, the condyle and dentoalveolar regions are extremely adaptive growth sites. Other regions are also constantly undergoing remodeling and growth. Muscle attachments are constantly adjusting to the growing face, while the functional environment develops. Once growth is completed, relative stability is attained and tissues assume a lower level of cellular turnover for maintenance of structures. At this stage, if the regenerative capacity of tissues is exceeded by tissue breakdown, degenerative changes occur. These changes are usually associated with an increased risk of development of signs and symptoms of TMJ internal derangement. The clinician should be aware that individuals experiencing TMJ internal derangement as adolescents may not present with significant signs and symptoms at an early age, but may convert to symptomatic patients once growth has ceased. Furthermore, the loss of condylar structure associated with the degenerative process may be interpreted as a relapse of orthodontic correction if treatment had been attempted at an earlier age. Symptoms of internal derangement may now erroneously be ascribed to the orthodontic treatment which was completed a few years prior to the onset of the symptoms.

## 8.7 Conclusions

Evaluation of craniofacial morphology making use of multivariate statistical techniques with MRI determined TMJ internal derangement as the dependent variable shows that a number of independent cephalometric variables may explain the variability in the dependent variable. This shows that associations do exist between internal derangement and craniofacial morphology in an adolescent female sample.

No cause and effect association between internal derangement and alterations in facial morphology can however be made. Internal derangement may be a consequence of abnormal biomechanical function associated with altered craniofacial morphology, or may occur due to some unknown factor. Longitudinal evaluation of these growing individuals may give an indication of the extent of facial changes occcurring in individuals with internal derangement, but until all factors influencing growth are investigated more thoroughly no cause and effect may be claimed. Longitudinal investigation may aid in determining which patterns of internal derangement are most prone to development of total disc displacement with development of craniofacial pain and dysfunction.

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# CHAPTER 9

## Male Adolescent Facial Pattern associated with TMJ Disc Displacement and Reduction in Disc Length

### 9.1 Introduction

Dental practitioners continually strive to understand and determine which factors influence craniofacial morphology and how these factors may be controlled to provide the best treatment outcome for patients. Adolescents show great adaptation and change in both dental and skeletal facial components as maturity approaches. During the process of growth the facial components may be exposed to a number of local environmental influences such as trauma, infection, inflammation, allergies, systemic and hormonal diseases, as well as orthodontic forces. These factors may alter the normal adaptive capacity of the growing tissues and modify facial morphology.

Associations between altered craniofacial morphology and localized environmental disturbances have been presented in the literature. Nasal obstruction and altered head position[1,2], condylar hypoplasia[3] and juvenile rheumatoid arthritis[4,5] all present with varying degrees of mandibular growth alteration affecting craniofacial morphology. These factors may be considered to be local environmental forces which influence facial development.

Normal function of the articular disc is to distribute the load from mastication throughout the temporomandibular joint (TMJ), to reduce friction and shearing forces[6] and provide a pumping mechanism for distribution of nutrients and oxygen suspended in synovial fluid to articular surfaces[7]. Loss of normal disc position may compromise normal joint function and muscle activity. The disturbance may be significant enough to interrupt cartilage matrix and proteoglycan production and produce morphologic remodeling of the articular surfaces. Internal derangement may therefore also be considered as a local environmental disturbance with potential to influence condylar development.

Recent studies suggest that TMJ internal derangement may be associated with altered facial morphology. Nebbe *et al*[8] were able to show differences in facial pattern between two groups of female adolescents, one group with bilateral normal disc position, and the other with bilateral full disc displacement as defined by magnetic resonance imaging (MRI) evaluation. This study showed that disc displacement may also be regarded as a localized disturbance in the environment of the mandibular condyle. A similar association between internal derangement and altered facial morphology could not be shown in a sample of adolescent males, since the number of males exhibiting bilateral internal derangement was too small for evaluation.

In a subsequent evaluation, the authors subjected data from the complete female sample to multiple regression statistical techniques to determine if cephalometric variables could explain the variability in quantitatively determined internal derangement[9]. This study included all females regardless of whether disc status was normal, partially displaced, or totally displaced as determined by quantitative assessment. Once again, the variables included in the regression equation described facial patterns indicative of reduced condylar development[9]. Internal derangement was associated with a reduction in posterior facial height, increased anterior face height, reduced mandibular corpus length and increased inclination of the mandible relative to cranial reference planes.

Previous studies which have attempted to investigated the association between cranio-mandibular disorders and altered craniofacial morphology have however not had the benefit of direct imaging of TMJ disc position and morphology[10-18]. These studies relied on radiographic interpretation of osseous joint morphology[13], clinical investigation for signs of craniomandibular dysfunction (mandibular mobility, pain on muscle palpation, and joint signs and symptoms) to establish associations between altered TMJ function and craniofacial morphology[14,18]. These assessments, however, lacked sensitivity and specificity for determining TMJ disc position.

Considering that facial patterns have been shown to be associated with disc displacement in the female adolescent population using multiple regression techniques, it remains to be seen whether similar facial patterns as described in the female sample can be described in a male sample exhibiting various degrees of disc displacement and reduction in disc length.

## 9.2 Methods and Materials

Information was gathered from 75 male subjects who presented for orthodontic consultation to the graduate orthodontic program at the University of Alberta or private orthodontic practices in the area. None of the subjects had previous orthodontic treatment and none had previously been diagnosed with juvenile rheumatoid arthritis. All males between the ages of 10 and 17 years were included in the study regardless of present or past TMJ signs and symptoms (capsular pain; joint sounds; masticatory muscle tenderness; limited mandibular range of motion; deviation on opening). All individuals consented to inclusion in the study which was approved by the Joint Dentistry/ Pharmacy Human Ethics Committee.

Facial proportions and cephalometric dimensions were evaluated by making use of closed- and open-mouth lateral cephalometric radiographs while the subjects were uniforming positioned in a Siemens OP10 cephalostat. Closed mouth lateral cephalometric radiographs were obtained for each subject, making use of a polyvinylsiloxane centric occlusion bite registration (President Jet-Bite, Coltene/ Whaledent Inc. Mahwah, NJ USA), which was also used for bite registration for MRI of the TMJs.

Open-mouth images were used to obtain an accurate outline of the condyle by superimposing the closed-mouth tracing of the symphysis, the lower border of mandible, developing dental follicles and enamel organ where present, on the open-mouth image. This facilitated measurement of vertical and sagittal facial proportions and angular and linear cephalometric dimensions in the various facial regions. Lateral cephalometry is however a two-dimensional representation of a three-dimensional structure and is limited by the superimposition of bilateral structures. On lateral cephalographs it is often impossible to differentiate right from left when bilateral structures are imaged, so in this study a single averaged measurement was used to represent bilateral structures identified. The angular and linear cephalometric variables employed in this study are listed in Table 9.1 and 9.2 respectively, together with a description of the anatomic landmarks[19].

The lateral cephalometric radiographs were traced by a single investigator, and retraced approximately two weeks later. The tracings were digitized using a Summasketch II digitizing tablet and a cross-hair cursor. The angular and linear digitized data was recorded by making use of a custom designed program based on Microsoft Visual Basic software. Repeat digitization error by replacement of the cursor on the same point was calculated to be 0.00 mm with a standard deviation of 0.11 mm.

A 1.0 T magnet (Shimadzu Corporation 3, Tokoyo, Japan) with a unilateral 3 inch surface receiver coil was used to produce MRIs of the TMJs. T1-weighted 500/20 (TR ms/ TE ms) pulse sequences were performed on all subjects using a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204. Initial axial scout images were obtained to identify the long axis of the condyles. The same polyvinylsiloxane centric occlusion bite registration used to record the bite registration for cephalometric evaluation was used to obtain bilateral closed-mouth coronal and sagittal images. The coronal images were obtained parallel to the condylar long axis, while sagittal images were formatted perpendicular to the long axis of the condyle. Open-mouth sagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening. Subjects were instructed to rest the incisor teeth on the blades of the caliper while imaging was carried out.

| **Name** | **Description** |
|---|---|
| N-S-Ba | Nasion - Sella - Basion |
| SN/Ar-Go | Sella - Nasion/ Articulare - Gonion |
| FH/Ar-Go | Frankfort horizontal/ Articulare - Gonion |
| FH/Co-Or | Frankfort horizontal/ Condylion - Orbitale |
| BaN/Ptm-Gn | Basion - Nasion/ Pterygomaxillary point - Gnathion |
| UI-LI | Upper Incisor/ Lower Incisor |
| LI/Go-Me | Lower Incisor/ Gonion - Menton |
| UI/ANS-PNS | Upper Incisor/ Anterior Nasal Spine - Posterior Nasal Spine |
| Ar-Go-Me | Articulare - Gonion - Menton |
| SN/ANS-PNS | Sella - Nasion/ Anterior Nasal Spine - Posterior Nasal Spine |
| SN/Go-Me | Sella - Nasion/ Gonion - Menton |
| FH/Go-Me | Frankfort horizontal/ Gonion - Menton |
| ANS-PNS/Go-Me | Anterior Nasal Spine - Posterior Nasal Spine/ Gonion - Menton |

Table 9.1: Angular Cephalometric Variables

| Name | Description |
|---|---|
| SN | Sella - Nasion |
| S-Ba | Sella - Basion |
| S-Co | Sella - Condylion |
| S-Ar | Sella - Articulare |
| S-Go | Sella - Gonion |
| SN-PNS | Posterior Nasal Spine perpendicular to Sella - Nasion plane |
| Ba-N | Basion - Nasion |
| N-ANS | Nasion - Anterior Nasal Spine |
| ANS-Me | Anterior Nasal Spine - Menton |
| N-Me | Nasion - Menton |
| 6/ANS-PNS | Maxillary mesiobuccal cusp tip perpendicular to palatal plane |
| Ptm-ANS | Pterygomaxillary fissure point - Anterior Nasal Spine |
| Co-Go | Condylion - Gonion |
| Ar-Go | Articulare - Gonion |
| Co-Me | Condylion - Menton |
| Ar-Me | Articulare - Menton |
| Go-Me | Gonion - Menton |
| LI/Go-Me | Lower Incisor Tip perpendicular to Gonion - Menton plane |

Table 9.2: Linear Cephalometric Variables

The same investigator traced each of the sagittal closed-mouth MRI slices produced for each joint. The outline of the condyle, posterior slope of the articular eminence, and the sagittal image of the disc was traced on each sagittal joint slice. This was done to determine the relationship between the osseous articular structures and the articular disc.

Reference planes from corresponding lateral cephalometric tracings were transferred to the MRI tracings according to the previously described technique[20]. The addition of these planes facilitated the measurement of disc length and disc displacement on each sagittal MRI slice of each joint.

## 9.3 Error of Method

Intra-rater reliability coefficients (Rel = 1-1/F)[21] for thirty-one cephalometric variables were determined by making use ten radiographs that were retraced on five separate occasions[21]. The lowest intra-rater reliability coefficient (Rel = 1-1/F) for all cephalometric variables was 0.97. This represents almost prefect agreement between tracing measurements, and therefore repeat measurements were averaged to produce a single average cephalometric measurement which was utilized in further analyses.

In addition to reliability coefficient computations (ANOVA methods), standard deviations for cephalometric variables were calculated over all tracings, as well as over all subjects. Three cephalometric variables emerged as having error of measurement greater than 1 degree (UI/LI 1.72$^0$; LI/Go-Me 1.19$^0$; UI/ANS-PNS 1.35$^0$). These variables were considered in the study but results should be interpreted with caution.

Determination of the coefficient of intra-rater reliability (Rel = 1-1/F) for disc length and disc displacement were computed by selecting ten MRI's representative of normal disc position, and ten representative of disc displacement. These twenty MRI's were retraced five times each on consecutive days to determine the error of measurement. Coefficient of intra-rater reliability (Rel = 1-1/F) for disc length and disc displacement were computed to be 1.00 and 0.98 for disc displacement and disc length respectively.

### 9.4 Data Analysis

Of the original 75 adolescent male subjects investigated, 5 were excluded from further analysis due to poor cephalometric quality or motion artifacts during MRI investigation of the TMJs. This provided a sample of 70 male adolescents for which lateral cephalometric radiographic of the facial region, and MRIs of the TMJs were available. Thirteen angular and 18 linear cephalometric measurements were recorded for each subject included in the study. In addition, linear measurements of disc displacement (DD) and disc length (DL) were recorded on sagittal closed mouth MRI slices of the TMJ. A multiple regression model was chosen as the statistical model most appropriate to interpret the associations between TMJ disc status and craniofacial cephalometric measurements.

#### 9.4.1 Independent Variable

The 31 cephalometric variables were utilized to form independent variables for multiple regression analyses. These original variables could not be entered without controlling for the effect of age, since it has been shown that relationships exist between cephalometric variables and age[19]. That is, the growth of a region may be relatively slow prior to the onset of the pubertal growth spurt, show a rapid increase in dimensions during the period of active growth, and then plateau off once early adulthood is approached. Observing the pattern of growth in a specific facial region provides two important pieces of information:

1. Increases in facial cephalometric dimensions do not occur in a linear fashion.
2. Growth of a facial region is age dependent.

Multiple regression analyses are linear models used to fit the independent variables to the dependent variable. Since cephalometric variables do not respond in a linear fashion with increasing age, subjecting this non-linear data to linear regression models to determine linear relationships between dependent and independent variables may be problematic. Polynomial regression techniques may be utilized to improve the fit of data to multiple regression models when second order curves exist as described for age related cephalometric changes[22].

Quadratics of independent variables, variable squared ($V^2$); variable cubed ($V^3$), may be computed and included as independent variables in the regression model. In this study a quadratic variable ($variable^2$) was included for all 31 independent variables, while $age^2$ and $age^3$ were included as quadratic variables for the age of each individual. This was done to improve the fit of this non-linear data.

If cephalometric variables are age dependent, then entering age into a multiple regression analysis will provide age dependent differences which may be difficult to distinguish from real differences associated with the dependent variable. It is therefore desirable to control for age so that observed differences may be free of the effect of age. The effect of age was controlled by first running multiple regression equations for each cephalometric variable with age, $age^2$ and $age^3$ as the independent variables, and the variable of interest as the dependent variable.

Example: $Y_1 = a + b_1X_1 + b_2X_2 + b_3X_3 + e$

where $Y_1$ is any variable (cephalometric or MRI)

$X_1 = \text{age}$; $X_2 = \text{age}^2$; $X_3 = \text{age}^3$

A regression equation produced a constant (Y intercept), regression coefficients for each of the independent variables, and residuals when age, $age^2$ and $age^3$ were regressed against the dependent variable. In the regression equation the Y intercept was an indication of the magnitude and direction of the association between the dependent variable and the regression equation. The residual in the regression equation was the numerical component of the dependent variable which was unexplained by the independent variables, age, $age^2$

and age$^3$. If the residual was large, then age variables did not explain the behaviour of the dependent variable, and vice versa.

A new variable was now computed for each of the previous variables, either actual measurement variable or formed quadratic variable. The new variable score for each subject was formed by adding the residual value computed for each subject to the constant produced for the particular variable when regressed against age, age$^2$ and age$^3$. In this way a new dependent variable for the 62 new independent cephalometric variables were created, all free of the effect of age.

### 9.4.2 Dependent Variable

Two dependent variables were identified, namely disc displacement (DD) and disc length (DL). Most statistical packages are however not capable of managing two dependent variables, so a single variable was generated making use of a Principal component analysis (SPSS for Windows, SPSS Inc. Chicago, IL).

This necessitated running Principal component analyses (PCA) for all DD measurements for all slices of each left and right joint separately. This provided a single DD score for each joint. For each subject the right and left PCA score was added to produce a composite score of DD for the subject, so that this data could be matched to the independent variable data.

It was previously shown that a negative association exists between measures of DD and DL[20]. That is, as measures of DD increase the measurement of DL decreases. Since DD and DL measures were to be reduced to a single dependent variable it was considered prudent to convert Disc length (DL) measures to reciprocal DL measures so the the two measures of disc status could proceed in the same relative direction. Reciprocal disc length was determined by subtracting the DL from what was considered to be normal disc length (10.00 mm)[20].

Example: If disc length was measured to be 7.37 mm, then reciprocal disc length measurement was: 10 - 7.37 = 2.63 mm

Principal component analysis was once again used to assign a single score of reciprocal DL to each joint. As for DD scores, the reciprocal DL scores for right and left joints were added to provide a single score for each subject. The scores for DD and for reciprocal DL were now entered into a PCA to produce a single weighted score for both joints for each subject. As for the independent variables, the dependent variable was regressed against age, age$^2$, age$^3$ to control for the effect of age on the dependent variable. This new PCA age controlled score was used as the dependent variable in the multiple regression analyses, and is a measure of internal derangement in both TMJs per subject.

### 9.4.3 Multiple Regression Models

All independent variables, age controlled cephalometric or quadratic, were divided into five groups and five different regression analyses were performed to determine associations between the independent variables and the dependent variable in each of the facial regions of interest (Table 9.3):

| Facial Region | Number of cephalometric variables entered |
|---|---|
| Cranial base | 14 |
| Maxilla | 14 |
| Mandible | 16 |
| Mandibular position | 10 |
| Dentition | 10 |

Table 9.3: Number of Cephalometric Variables included in each Regression Equation

In each regression model all independent variables were entered into the initial regression equation. Variables which did not contribute significantly to explaining the variability in the dependent variable were then removed from each model in a sequential stepwise manner until only significant independent variables remained in the model. This forced entry multiple regression model was employed in preference to the Stepwise regression model. The forced entry models are analagous to a Backward regression model with the exception that all insignificant variables are removed from the models prior to determining the complete regression equations[22]. In other words, in each of the five models all independent variables which contribute to explaining the variability in the dependent variable are included in each of the models. Stepwise regression on the other hand, determines the simplist model with the fewest independent variables entered in the equation and does not include all variables that contribute to explaining the variability in the dependent variable.

## 9.5 Results

Results of the Multiple regression analyses in each of the facial regions described are presented in Table 9.4. In certain instances, variables may have been excluded from the regression equation for a particular facial region if they were highly correlated with cephalometric variables already in the equation. Table 9.5 presents the computed Pearson correlation coefficients for the various facial regions where independent variables already included in an equation were highly correlated with variables not in an equation.

### Cranial Base

A single cranial base cephalometric variable and its quadratic variable were included in the regression equation for this region. The measurement from Sella to Articulare (S-Ar) on the neck of the mandible showed a negative association with the dependent variable. This variable was however highly correlated with S-Co and S-Ba, two other vertical posterior cranial base measurements (Figure 9.1).

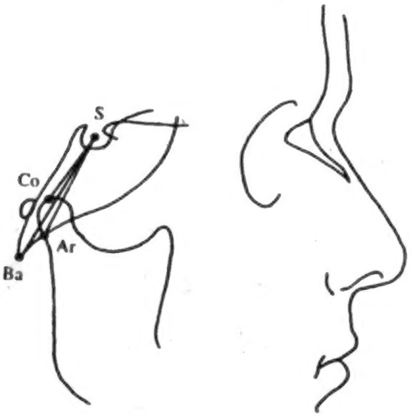

Figure 9.1: Cranial Base Variables entered into the Multiple Regression Equation
(* variables highly correlated with variables entered into the eqation)

These results may be interpreted to mean that with increasing severity of internal derangement, there is a reduction in the height of the posterior cranial base. The adjusted R-squared value for the regression equation was however very low at 0.04. No associations between sagittal cranial base measurements or cranial base flexure and the dependent variable were noted. The lack of these associations in the male sample differentiates it from the female sample studied previously which exhibited negative associations between SN, Ba-N, N-S-Ba and the dependent variable.

| Facial Region | Independent Variable | Significance | Correlation Coefficients | Adjusted R-Squared |
|---|---|---|---|---|
| **Cranial Base** | **S-Ar** | 0.039 | -0.095 | 0.040 |
| | **S-Ar*** | 0.043 | -0.080 | |
| **Maxilla** | **ANS-PNS/Go-Me** | 0.000 | +0.504 | 0.243 |
| **Mandible** | **Co-Me** | 0.023 | -0.102 | 0.423 |
| | **Co-Me*** | 0.025 | -0.077 | |
| | **Ar-Me** | 0.003 | -0.201 | |
| | **Ar-Me*** | 0.009 | -0.183 | |
| | **Go-Me** | 0.021 | -0.176 | |
| | **Go-Me*** | 0.037 | -0.156 | |
| | **Ar-Go** | 0.001 | -0.265 | |
| | **Ar-Go*** | 0.000 | -0.219 | |
| | **Ar-Go-Me** | 0.041 | +0.217 | |
| | **N-Me** | 0.004 | +0.299 | |
| **Mandibular Position** | **SN/Go-Me*** | 0.000 | +0.474 | 0.213 |
| **Dentition** | **UI/LI** | 0.000 | -0.019 | 0.210 |
| | **LI/Go-Me* (angle)** | 0.000 | -0.234 | |
| | **UI/ANS-PNS*** | 0.001 | -0.108 | |

* Superscript 2 denotes quadratic variable

Table 9.4: Variables Included in Multiple Regression Equations

**Maxilla**

Cephalometric variables which assessed the sagittal and vertical dimensions of the maxilla and the posterior maxillary dentition were not included in the regression equation and did not contribute to explaining the variablity in TMJ internal derangement. Only ANS-PNS/Go-Me was included in the regression equation and showed a positive association with the dependent variable. The measured value of this variable may increase as a result of an increase in the mandibular plane angle rather than a change in the measured angulation of the palatal plane relative to cranial reference planes. Measures of lower anterior facial height (ANS-Me) were highly correlated with ANS-PNS/Go-Me. Both cephalometric variables however explain the same facial changes (Figure 9.2).

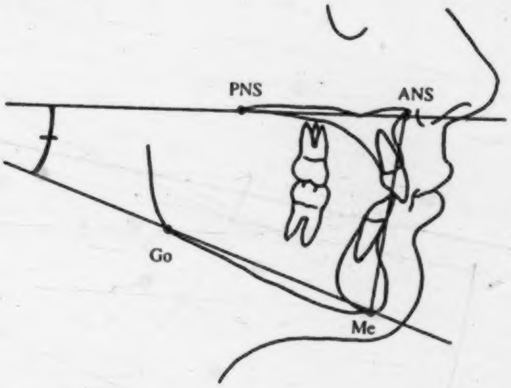

Figure 9.2: Maxillary Variables entered into the Multiple Regression Equation

(* variables highly correlated with variables entered into the eqation)

In the regression equation previously determined for the female sample, SN/ANS-PNS and 6/ANS-PNS as well as ANS-PNS/Go-Me contributed significantly to explaining the variability in the dependent variable. Therefore in the female sample, an increase in the angulation of the palatal plane relative to SN, and a reduction in the maxillary first molar height was observed to be associated with an increase in severity of TMJ internal derangement.

| Facial Region | Variable in Equation | Correlated Variable | Correlation |
|---|---|---|---|
| **Cranial Base** | **S-Ar** | **S-Co** | +0.811 |
| | **S-Ar** | **S-Ba** | +0.758 |
| **Maxilla** | **ANS-PNS/Go-Me*** | **ANS-Me** | +0.753 |
| **Mandible** | **Ar-Go** | **Co-Go** | +0.814 |
| | **Ar-Go** | **S-Go** | +0.849 |
| **Mandibular Position** | **SN/Go-Me*** | **FH/Go-Me** | +0.870 |
| | **SN/Go-Me*** | **BaN/Ptm-Gn** | -0.768 |

* Superscript 2 denotes quadratic variable

Table 9.5: Independent Variables Correlated with Independent Variables in Equation

**Mandible**

The adjusted R-squared for cephalometric variables included in the equation for this facial region was 0.423. The cephalometric variables included in the regression equation for male sample were essentially identical to those included in the regression equation for the female sample. The only difference between the two groups was that Co-Go and S-Go were expressed in preference in the female sample to Ar-Go for measurements of posterior vertical facial and mandibular height.

Cephalometric variables which expressed vertical and sagittal dimensions of the mandible all showed significant decreases in magnitude as the degree of internal derangement increased (Figure 9.3). Mandibular sagittal length represented by measurements of Co-Me, Ar-Me and Go-Me were included in the regression equation and showed a negative association with increased degrees of internal derangement. Vertical ramus height (Ar-Go) and total anterior facial height (N-Me) were the vertical cephalometric measurements included in the regression equation. Total anterior facial height (N-Me) showed an increase, while Ar-Go showed a decrease with increased severity of internal derangement. Articulare - Gonion was highly correlated with Co-Go and S-Go. This illustrates that measurements of total posterior facial height (S-Go) and ramus height (Co-Go) may provide similar information to measurements of Ar-Go.

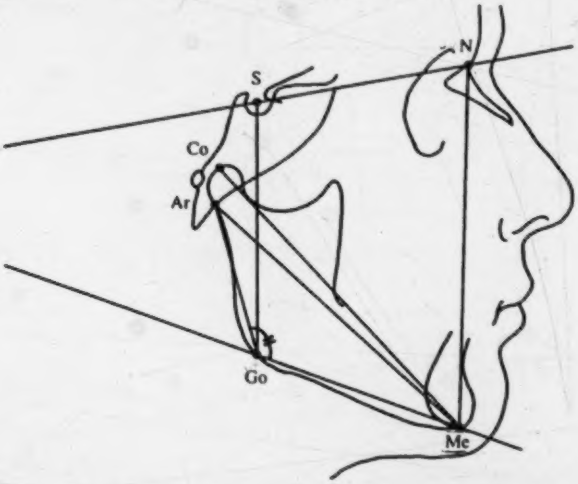

Figure 9.3: Mandibular Variables entered into the Multiple Regression Equation
(* variables highly correlated with variables entered into the eqation)

In both the male and the female samples, Ar-Go-Me showed a positive association with the dependent variable and contributed towards explaining the variability in measurements of internal derangement of the TMJ.

**Mandibular Position**

A single cephalometric variable remained within the regression equation and explained the position of the mandible relative to the dependent variable. The adjusted R-squared for this equation was 0.213. The mandibular plane angle relative to Sella - Nasion (SN/Go-Me) showed a positive association with the dependent variable. In addition, SN/Go-Me was highly correlated with FH/Go-Me and BaN/Ptm-Gn. These cephalometric variables provide similar information to the independent variable already included in the equation.

As far as mandibular position is concerned, there was no difference between the male sample and the previously studied female sample with regards to which variables were entered into the regression equation. Therefore the response of the independent variables for the mandible, relative to the dependent variable, were essentially identical for the two groups investigated.

### Dentition

Cephalometric variables which identified the position of the anterior dentition were included in the regression equation for this region. Unlike the previously studied female sample, the variable which described the position of the maxillary permanent first molar was not included in the regression equation. All dental cephalometric variables entered into the equation, (UI/LI, LI/Go-Me, UI/ANS-PNS) were angular measurements which showed a negative association with the dependent variable. The adjusted R-squared was 0.21.

The results concerning the dentition should be interpreted with caution as measurement error was greater than 1 degree for all three cephalometric variables. Therefore the power of association may not be as strong as indicated even though the variables were entered into the equation.

## 9.6 Discussion

The males included in this study were similar to the female sample previously investigated, in that both groups comprised individuals with and without MRI determined disc displacement. Although differences in age may have occurred between the two samples, age differences were eliminated by making use of regression equation techniques. In this way residual and constant values were computed when age variables were entered as the independent variables, and cephalometric variables were used as the dependent variables. This permitted new cephalometric variables to be determined which were free of the effect of age.

Differences were however evident between males and females in three of the five facial regions investigated, namely cranial base, maxilla, and the region of the dentition. In the mandibular region, cephalometric variables which described the vertical and sagittal dimensions of the mandible as well as the mandibular position in relation to the dependent variable, were similar in both the male and the female groups. This finding is of considerable interest, since if internal derangement is to be considered as a localized alteration in the functional environment of the face, it would be expected to have its greatest impact on condylar, ramal and mandibular morphology due to the location of the functional disturbance created by the disc displacement. It therefore appears that an association between internal derangement and altered mandibular morphology can be shown and is not gender dependent.

The etiology of the disc displacement may not be known, but the mechanisms involved in establishing the associations shown in this study may be explained by the pathophysiology involved in the process of disc displacement. Initial elongation of discal attachments is assumed to take pace with disc displacement. As discal attachments are elongated the disc becomes progressively displaced and the normal function of the disc is disturbed[23]. The degree of disturbance in biomechanical function of the joint depends on the extent of disc displacement and abnormal contact between adjacent joint surfaces. A disc which is fully displaced offers the osseous articular surfaces no protection from masticatory forces. Shock absorption and load distribution provided by the disc is no longer present[24]. Moreover, the movement of synovial fluid which bathes, lubricates and nourishes the joint is interrupted due to loss of pumping action provided by the disc during mastication[7]. These intra-articular changes are the beginning of further biochemical, cellular, histological and morphological changes to affect the articulation.

A large component of the articular disc and articular cartilage is composed of aggregates of extremely hydrophilic proteoglycans which are intertwined throughout a collagen framework forming the matrix of the tissue. The matrix expands placing tension on the collagen fibrils due to the ability of the proteoglycans to bind water[25]. The percolation of fluid through the matrix components of the articular surfaces allows for nutrient and waste exchange which is crucial to the maintenance of these tissues.

Excessive load distribution to joint surfaces as a result of disc displacement produces collagen fragmentation with release of proteoglycans and water into the joint spaces. Products of tissue damage and proteinaceous exudate of inflammation attract more fluid into the joint spaces increasing the intra-articular pressure. Raised intra-articular pressure decreases blood flow, producing hypoxia during load application and mandibular function[26]. Hypoxia may in turn impair cellular proliferation and matrix synthesis, contributing to cartilage loss and decreased regenerative capacity of the tissue[27].

Released degradation products from tissue breakdown and damage are removed from the joint space by phagocytosis of macrophages located within the synovial membrane. Once activated these cells produce cytokines and/ or metalloproteinases which in turn stimulate chondrocytes to anabolic matrix forming functions or catabolic matrix degrading activity[28]. The expression of proteases by chondrocytes inhibits matrix synthesis and chondrocyte proliferation, resulting in cartilage resorption[29]. A balance between anabolic and catabolic activity within the articular cartilage maintains the integrity of the tissue, but once the equilibrium is disturbed a thinning of the articular cartilage may be seen. The cycle is exacerbated by continuous load on less elastic articular tissues, causing further cell damage, release of more proteolytic enzymes, and further degradation of the matrix.

Tissue damage and inflammation together with the released prostaglandins has an effect on the afferent information from articular receptors. This may result in modification of efferent impulses to the muscles of mastication which participate in joint loading. At least initially this may cause muscle splinting and muscle weakness which may lead to disuse muscle atrophy[30]. At a later stage muscle function and range of movement of the joint may appear normal but the degree to which muscle strength and patterns of contraction are permanently affected is unknown.

Macroscopically, alterations in disc architecture are noted as a consequence of disc displacement. These changes can be summarized as shrinkage and fibrosis of the posterior attachments as a pseudodisc is formed[31]. The fibroarticular cartilage covering the osseous articular surfaces may show both proliferative and resorptive changes localized to various regions of the condyle depending on the load distribution of the involved surfaces. The temporal component of the joint shows similar cartilaginous changes. With the progress of time both osseous articular components show flattening and changes consistent with remodeling and subchondral thickening[32].

Advanced remodeling and decreased proliferative potential of chondrocytes to form matrix and cartilage is accompanied by a reduced condylar contribution to vertical ramus height. A reduction in the quality and quantity of matrix produced by the proliferative cellular layer reduces the amount of tissue available for conversion to osseous structures. The equilibrium between continuous condylar remodeling that occurs as the result of normal function, and proliferation of condylar tissue which occurs during adolescent growth, may be disturbed with a resultant shift in equilibrium toward tissue debt and loss of incremental height gain of the condyle and ramus. Normally, remodeling of the ramus occurs which benefits the increase in sagittal dimensions of the mandibular corpus. Reduced condylar contribution to ramal height and reduced ramal contribution to mandibular corpus development results in an overall reduction in the size of the mandible.

A cause and effect relationship between internal derangement and altered craniofacial morphology cannot be made even though associations between internal derangement and altered craniofacial morphology have been shown. The use of literature as cited above may be supportive but not conclusive in identifying the exact process occurring in the adolescent TMJ. The contribution of normal muscle function, hormonal influences, environmental factors and genetic potential on facial development all need to be considered. It should however be noted that disc displacement may be considered another potential environmental factor which may influence facial form.

## 9.7 Conclusions

This study showed that when multivariate statistical techniques were applied the greatest associations between internal derangement and altered craniofacial morphology occurred in the osseous structures most closely approximated with the TMJ articulation. The lateral posterior cranial base, which forms the superior articulation of the joint, showed a superior positioning of the condyle relative to the posterior cranial base structures.

Cephalometric variables employed to determined the position and dimensions of the inferior articulation of the TMJ (ie. the mandible) showed a reduction in sagittal and vertical measurements when used to explain the variability in the TMJ dependent variable. The corpus length of the mandible and vertical ramus height showed a negative association with increasing internal derangement measures. An increased mandibular plane angle to SN and an increase in the gonial angle of the mandible (Ar-Go-Me) were also shown to be associated with increased TMJ internal derangement.

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# CHAPTER 10

## Clinical Evaluation of Female Adolescents Based on MRI Determination of TMJ Disc Status

### 10.1 Introduction

Craniomandibular disorders (CMD) are characterized by pain in the temporomandibular joints, muscles of mastication, by limited mandibular motion, the presence of joint sounds, deviation on mouth opening and pain on movement. Disc displacements, myofascial pain, and osteoarthrosis are some of the disorders which are considered under the broad category of CMD. Each of these disorders affects a different tissue of the craniomandibular region, yet produce signs and symptoms that are much the same.

Clinical examination and a comprehensive history are used to obtain information on the craniomandibular region and status of the temporomandibular joint (TMJ). This clinical information has however been shown not to be reliable in determining the incidence of disc displacement[1,2]. The evaluation of joint sounds has been particularly difficult to explain. It has been suggested that the presence of TMJ sounds should not be interpreted as a disc displacement, nor should the absence of joint sounds lead the investigator to believe that the joint is normal[3,4]. A history of joint sounds may however be important in instances where joint sounds were present but are no longer evident. This may lead the clinician to believe that a once displaced and reducing disc, is no longer reducing.

An assessment of joint and muscle tenderness is often not specific for TMJ disc displacement. Joint tenderness may be associated with tenderness of adjacent musculature or may be a feature of capsular inflammation. Muscle tenderness may occur as a result of muscle overuse and parafunction, or as part of a myofascial pain disorder. To complicate matters, the significance of muscle tenderness, and the interpretation of these findings are still unclear. In addition, the observer relies on subjective responses which are difficult to standardize, and are dependent on the subject's previous experiences and cultural background[5].

Deviation in mandibular motion and an alteration in the quantity and quality of condylar translational movements are good indicators of disc displacement but are also not specific for this condition[6]. Limited mouth opening and deviation of the mandible during opening can also occur in cases of unilateral myofascial pain dysfunction[7]. In summary, clinical information is an indicator of alteration in normal function, but does not seem to identify specific alterations in disc position.

Epidemiologic studies of populations of children and adults have made use of clinical information on craniomandibular disorders in an attempt to determine the prevalence and etiology of the disorder[8-10]. The problems these studies have encountered can be enumerated as follows:

1. Craniomandibular disorders encompass a group of disorders, and therefore the etiology should be considered to be multifactorial,
2. Discrete well-defined signs and symptoms have not been identified for the broad category of craniomandibular disorders,
3. Soft tissue imaging of the temporomandibular joint is necessary to rule out the presence of disc displacement.

If signs and symptoms of craniomandibular disorders are to be appreciated, the component disorders should be investigated independently.

At this stage there appears to be no consensus as to which clinical signs and symptoms facilitate selective differential diagnosis of disc displacement from myofascial pain and osteoarthrosis. Currently, direct quantification of disc position is possible using MR images of the temporomandibular joint[11,12].

This study aims to determine whether clinical signs, symptoms and history can be used to differentiate between adolescent subjects with MRI determined bilateral total disc displacement, bilateral normal disc position and adolescents with varying degrees of disc displacement affecting the joints.

### 10.2 Methods and Materials

As part of a comprehensive evaluation of craniofacial morphology and disc status of the TMJ, 194 preorthodontic adolescent individuals aged 10 - 17 years (119 females and 75 males) were assessed for clinical signs and symptoms of internal derangement. Bilateral MRIs of the TMJs were obtained for each subject to assess disc position. The group consisted of subjects with and without clinically detectable TMJ signs and symptoms (capsular pain; joint sounds; masticatory muscle tenderness; limited mandibular range of motion; deviation on opening). All individuals consented to inclusion in the study which had previously been approved by the Joint Dentistry/ Pharmacy Human Ethics Committee. No individuals with a previous history or diagnosis of juvenile rheumatoid arthritis were included in the study.

Axial MRI scout images of the TMJs were performed to identify the long axis of the condyles. All images were produced making use of a 1.0 T magnet (Shimadzu Corporation 3, Tokyo, Japan) and a unilateral 3 inch surface receiver coil. Bilateral closed-mouth sagittal images were produced perpendicular to the condylar long axis, while coronal images were obtained parallel to the condylar long axis. Closed mouth images were obtained making use of polyvinylsiloxane (President Jet-Bite, Coltene/ Whaledent Inc. Mahwah, NJ) centric occlusion bite registration. Bilateral open mouth sagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening. All coronal and sagittal images were T1-weighted 500/20 (TR ms/ TE ms) with a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204.

All sagittal closed-mouth slices of the TMJ were traced by a single observer in an attempt to quantify disc status. Quantification was carried out making use of standardized reference planes and measurement techniques as previously published[12]. Measurements of disc length and disc displacement were produced for each sagittal closed-mouth MRI slice of the joint. These quantitative measures were used in a discriminant analysis to test 5 subjective categorical scores of disc status. The categories of disc position in the closed-mouth position were as follows (Figure 10.1):

1. *Normal disc position*

   The intermediate zone of the disc was interposed between the osseous articular surfaces, with the anterior and posterior bands equally spaced on either side of the condylar load point[13].

2. *Slight anterior displacement*

   The condyle apposed the anteriorly displaced posterior band of the disc since the intermediate zone was slightly displaced from between the osseous articular components.

3. *Moderate anterior displacement*

   The condyle was in contact with the junction between posterior band of the disc and the bilaminar zone, with the intermediate zone of the disc completely anteriorly displaced from between the osseous articular surfaces.

4. *Full displacement*

   The entire articular disc was anteriorly displaced relative to the loaded osseous articular surfaces. The bilaminar zone of the disc was interposed between the osseous articular structures and occupied the narrowest joint space. The intermediate zone of the disc was once again interposed between the osseous articular surfaces on mouth opening.

   (categories 1-4 all exhibited disc reduction on mouth opening)

5. *Full displacement of the articular disc with severe loss of morphology*

Identical description to category 4, but without reduction of the disc on mouth opening.

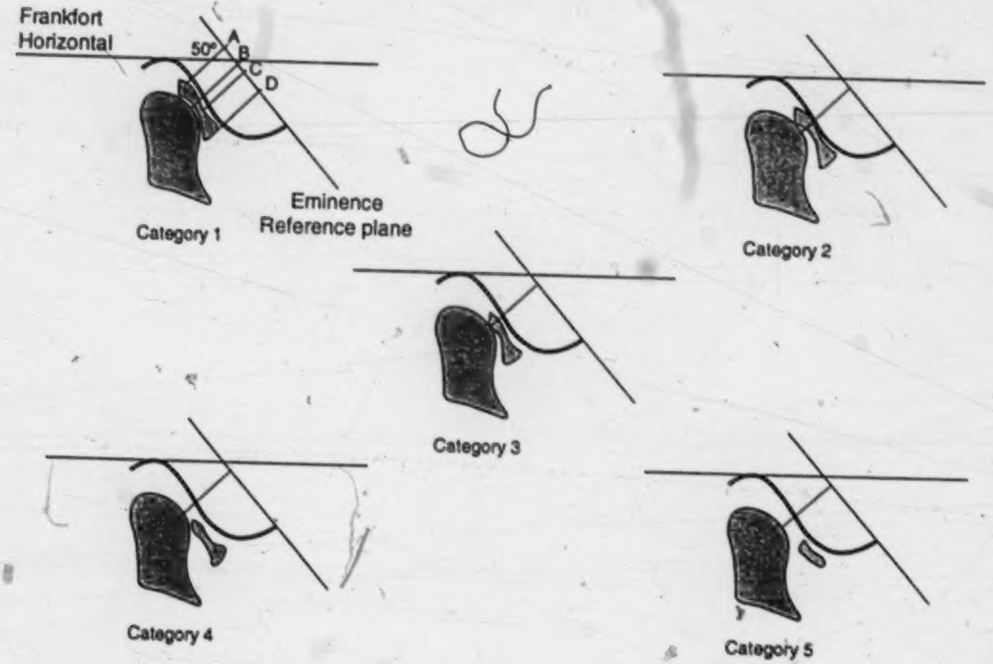
Frankfort Horizontal
50°
A
B
C
D
Eminence Reference plane
Category 1
Category 2
Category 3
Category 4
Category 5

Figure 10.1: Categories of Disc Position

On the basis of the discriminant analysis a categorical score between 1 and 5 was assigned to each temporomandibular joint slice produced by MRI[12]. Any joint therefore had between 3 and 6 categorical scores assigned to the joint, corresponding to the number of sagittal slices produced per joint. The discriminant scores per slice revealed that the following categorization per joint could be assigned:

- A joint was classified to a particular category (1,2,3,4,5) only if all sagittal MRI slices were categorized by discriminant analysis to that category. Category 4 (total disc displacement) and category 5 (total disc displacement with severe morphological alteration) were combined to form a single category denoted as "total disc displacement". All slices within a single joint had to be categorized as either category 4 or 5 to assign the joint to this category.

- No consistent scoring in a joint could be determined and the joint could not be classified into a single TMJ category.

The categorization of the joint based on MRI slice data was further utilized to establish three groups of individuals based on joint status:

1. Bilateral normal joint status: Both joints per subject were consistently scored as category 1.

2. Bilateral total disc displacement: Both joints per subject were consistently scored as either category 4 or 5.

3. Other: This group consisted of individuals who did not have bilateral normal or total disc displacement or who did not have consistent scoring throughout the joint.

Full clinical and MRI information was available on 148 of the original 194 individuals (89 females and 59 males). Fouteen subjects were excluded due to poor MRI quality, while the remainder failed to complete some portion of the clinical evaluation. The distribution of the subjects according to discriminant grouping of MRI joint slices and joints is presented in Table 10.1. Analysis of clinical signs and symptoms in males was not carried out since only 2 cases of bilateral disc displacement were present.

| **Discriminant Grouping** | **Females** | **Males** |
|---|---|---|
| Bilateral normal joints | 17 | 23 |
| Bilateral total disc displacement | 14 | 2 |
| Other | 58 | 34 |

Table 10.1: Discriminant Grouping of Sample based on Bilateral Joint Status

A complete head and neck physical examination and intra-oral examination was performed on all subjects by a single observer blinded to results of MRI interpretation of disc status. Clinical examination preceded the MRI investigation of the TMJ's. A stethoscope was used to detect joint sounds, digital palpation was performed on the muscles and capsular structures, and a millimetre rule was used to measure continuous variables. The signs and symptoms investigated were divided into four divisions for descriptive purposes (Tables 10.2 - 10.5). The divisions were as follows:

1. Signs of Temporomandibular Joint Dysfunction

   The quality and quantity of joint movement was assessed during the range of condylar translation. Dynamic assessment determined maximal mouth opening, protrusion and laterotrusive movements. Digital palpation was used to investigate signs of joint tenderness of the joint and stethoscopic investigation was used to determine the presence of joint sounds.

2. Signs of Masticatory and Cervical Muscle Tenderness

   Bilateral digital palpation of masticatory, accessory masticatory, cervical and intra-oral muscles was carried out to elicit a response regarding tenderness of the muscles.

3. Occlusal Assessment

   Static occlusal relationships assessed Angle molar relationship, linear measurements of incisal overjet and overbite measured with a millimeter scale accurate to 0.5 mm.

4. Clinical Symptom History.

   Subjective report concerning history of joint and muscle symptoms, facial trauma and habits were considered.

Continuous data were recorded with a millimeter rule accurate to 0.5 mm, while nominal categorical information scored as being either present (1) or absent (0). Information regarding signs and symptoms were obtained from each subject making use of the procedures outlined in Tables 10.2 - 10.5.

| **Variable** | **Score** | **Description** |
|---|---|---|
| Reproducible sound | nominal | Repeatable joint sounds audible with stethoscope on mouth opening or closing |
| Non-reproducible sounds | nominal | Intermittent joint sounds audible with stethoscope on mouth opening or closing |
| Early open click | nominal | Early opening click detected with stethoscope |
| Early close click | nominal | Early closing click detected with stethoscope |
| Mid-open/close click | nominal | Mid-range click detected with stethoscope |
| Late open click | nominal | Late opening click detected with stethoscope |
| Late close click | nominal | Late closing click detected with stethoscope |
| Lateral capsular pain | nominal | Pain perceived on light digital palpation of lateral capsular structures |
| Posterior capsular pain | nominal | Pain perceived on light digital palpation of posterior capsular structures |

|  |  |  |
|---|---|---|
| Superior capsular pain | nominal | Pain perceived on light digital palpation of superior capsular structures |
| Crepitus | nominal | Audible grinding sounds with stethoscope |
| Deviation | nominal | Deviation of mandibular midline relative to maxillary midline greater than 2 mm on mouth opening |
| Unassisted opening | continuous | Vertical mouth opening including overbite measurement |
| Assisted opening | continuous | Assisted digital pressure for vertical mouth opening including overbite measurement |
| Right laterotrusion | continuous | Maximal right shift of mandibular dental midline relative to maxillary dental midline on laterotrusion |
| Left laterotrusion | continuous | Maximal left shift of mandibular dental midline relative to maxillary dental midline on laterotrusion |
| Protrusion | continuous | Maximal anterior sagittal movement of lower central incisor relative to upper including overjet measurement |
| Unassisted opening pain | nominal | TMJ pain experienced on maximal passive mouth opening |
| Assisted opening pain | nominal | TMJ pain experienced on maximal assisted stretched mouth opening |
| Left laterotrusion pain | nominal | TMJ pain experienced in either joint on maximal left laterotrusion |
| Right laterotrusion pain | nominal | TMJ pain experienced in either joint on maximal right laterotrusion |
| Protrusive pain | nominal | Pain experienced in either joint on protrusion |

*nominal score : 0 = no abnormality detected; 1 = abnormality present

Table 10.2: Signs of Temporomandibular Joint Dysfunction

| Variable | Score | Description |
|---|---|---|
| Temporalis | nominal | Tenderness on digital palpation of anterior, middle and posterior bellies |
| Temporalis insertion (intra-oral) | nominal | Tenderness on digital palpation |
| Masseter | nominal | Tenderness on digital palpation of anterior, deep and inferior regions of muscle |
| Medial pterygoid (extra-oral) | nominal | Tenderness on digital palpation |
| Medial pterygoid (intra-oral) | nominal | Tenderness on digital palpation |
| Lateral pterygoid (intra-oral) | nominal | Tenderness on digital palpation |
| Posterior digastric | nominal | Tenderness on digital palpation |
| Vertex | nominal | Tenderness on digital palpation |
| Sternocleidomastoid | nominal | Tenderness on digital palpation of superior, middle and inferior regions of muscles |
| Trapezius | nominal | Tenderness on digital palpation of insertion and origin |

*nominal score : 0 = no abnormality detected; 1 = abnormality present

Table 10.3: Signs of Masticatory and Cervical Muscle Tenderness

| Variable | Score | Description |
|---|---|---|
| Anterior attrition | nominal | Clinically detected excessive wear on 3-3 |
| Posterior attrition | nominal | Clinically detected excessive wear on teeth distal to 3's |
| Overjet | continuous | Measure of horizontal distance between labial of lower central incisor to labial of upper central incisal edge |
| Overbite | continuous | Vertical overlap of upper incisor over lower incisor |
| Anterior RCP/ICP discrepancy | nominal | Anterior shift greater than 1 mm from retruded contact to intercuspal contact position |
| Vertical RCP/ICP discrepancy | nominal | Vertical shift greater than 1 mm from retruded contact to intercuspal contact position |
| Lateral RCP/ICP discrepancy | nominal | Lateral shift greater than 1 mm from retruded contact to intercuspal contact position |
| Molar relations | nominal | Intra-oral evaluation of angle molar relationship, Class II = (0), Class I = (1), Class III = (2) |

| | |
|---|---|
| *nominal score : | 0 = no abnormality detected; 1 = abnormality present |
| *continuous score: | millimetre measurements, measured to 0.5 mm accuracy. |

Table 10.4: Occlusal Assessment

The clinical response of subjects to palpation of bilateral structures or assessment of joint sounds was either positive or negative, and response was either bilateral or unilateral. The following scores were assigned to clinical signs or symptoms based on the response of the subject to clinical investigation:

- Score 1: Bilateral negative response to tenderness or detection of clinical sign,
- Score 2: Left side positive response, right side negative response,
- Score 3: Right side positive response, left side negative response,
- Score 4: Bilateral positive response to tenderness or detection of clinical sign.

| Variable | Score | Description |
|---|---|---|
| TMJ pain history | nominal | Subjective appreciation of present/ previous TMJ pain |
| TMJ sounds history | nominal | Subjective appreciation of present/ previous TMJ sounds |
| Headache history | nominal | History of recurrent headaches, more than 1/week |
| Neck pain history | nominal | Subjective appreciation of neck stiffness or tenderness which is persistent |
| Joint locking history | nominal | Previous or current open or closed joint lock |
| Mouth-breathing | nominal | Nocturnal/ diurnal history of mouth-breathing |
| Tonsillectomy | nominal | History of recurrent tonsillitis or tonsillectomy |
| Thumbsucking | nominal | Present/ previous history of thumb/ finger sucking |
| Facial trauma | nominal | History of trauma involving maxilla or mandible |
| Birth trauma | nominal | History of birth trauma or severe illness |
| Bruxism | nominal | Subjective appreciation of nocturnal/ diurnal para-functional habits |
| Earache history | nominal | History of recurrent earaches |
| Ear infection history | nominal | history of recurrent ear infections or ear drainage |

*nominal score : 0 = no abnormality detected; 1 = abnormality present

**symptom history was obtained in consultation with subject and guardian

Table 10.5: Clinical Symptom History

## 10.3 Statistical Analysis

Female subjects were classified into one of three groups depending on the MRI status of the joints; this information was used as the categorical dependent variable for ordinal logistic regression analyses. The presenting clinical signs and symptoms were assessed as scores for each subject, with the range of responses between 1 and 4. The categorical scores per clinical sign or symptom were used as the independent variables in the analysis. Ordinal logistic regression analysis was carried out independently for each of the divisions of clinical signs and symptoms (i.e. TMJ symptoms, muscle symptoms, occlusal assessment and subjective history). Thereafter, the clinical signs and symptoms significantly related to MRI grouping of joint status per division were entered into the final model to assess the relationship between MRI determined joint status and clinical signs and symptoms.

In all analyses a *p*-value of less than 0.05 was considered statistically significant. In addition to the logistic regression, Odds ratios were computed for all variables showing statistically significant differences in the presentation of clinical signs and symptoms.

## 10.4 Results

The results of the ordinal logistic regression analysis for females carried out for each division of clinical signs and symptoms are presented in Table 10.6 with the respective Odds ratios. In addition, Pearson correlation coefficients for variables entered into the equations and variables not entered into the equations were computed to determine if highly correlated variables were dropped from the equation to establish the simplest equation. Pearson correlation coefficients showed that no variable left out of any equation was highly correlated with a variable already included in the logistic regression equation. A final logistic regression model derived from the significant variables entered into the four logistic regression equations is presented in Table 10.6.

In the final female model only two variables were found to be significantly related to MRI-determined categorical grouping of disc position. Odds ratios indicate the odds of having bilateral total disc displacement in the presence of the identified clinical sign or symptom when all signs and symptoms are taken into consideration in a single model.

| Clinical Variables | Significance | Odds Ratio |
|---|---|---|
| **TMJ Dysfunction** | | |
| Lateral capsular pain$_3$ | 0.045 | 7.91 |
| Late open click$_3$ | 0.047 | 123.89 |
| **Muscular Symptoms** | | |
| Deep masseter$_2$ | 0.005 | 36.75 |
| Deep masseter$_4$ | 0.037 | 6.81 |
| **Subjective History** | | |
| Subjective TMJ sounds$_4$ | 0.011 | 3.46 |
| **Occlusal Assessment** | | |
| no variables entered | n.s. | - |
| **Final Model** | | |
| Deep masseter$_2$ | 0.004 | 38.87 |
| Subjective TMJ sounds$_4$ | 0.018 | 3.37 |

* subscript denotes which score of clinical signs and symptoms was significantly related to Group 2 (bilateral total disc displacement).

Table 10.6: Results of Ordinal Logistic Regression Analyses

### 10.5 Discussion

The inclusion of discriminant categories 4 and 5 into a single category was based on the functional significance of disc position. In both these categories the disc is fully displaced from between the osseous articular surfaces and the load of masticatory function is presumed to be distributed to the retrodiscal tissues. The retrodiscal tissues are highly vascularized and innervated, but poorly adapted to load distribution. Increased loading may be associated with the development of symptoms once these tissues become inflammed and damaged. Continuous loading of the retrodiscal tissues occurs in joints categorized as category 4 and 5, since the discs are fully displaced. Therefore, individuals with these forms of disc displacement may present with similar symptoms.

Ordinal logistic regression analysis of the clinical signs and symptoms related to temporomandibular joint dysfunction show that right-sided capsular pain is associated with MRI-determined bilateral total disc displacement. The odds of having right-sided lateral capsular pain is 7.91 times greater with total disc displacement than with the other groups of disc position (i.e. bilateral normal, other). Right-sided opening joint sounds was shown to occur 123.89 times more commonly when bilateral total disc displacement was identified on MRIs of the joint than other groups of joint position. In fact, in this sample right-sided joint sounds only occurred associated with bilateral total disc displacement, no right-sided joint sounds were evident in the group with bilateral normal disc position or in the group with some other disc position classified as "Other".

When logistic regression analysis was applied to clinical signs and symptoms associated with musculature in the orofacial region, only one muscle showed a significant relationship to MRI-determined disc position. The deep masseter was included in this model and showed that when left-sided deep masseter tenderness occurred it was 36.75 more likely to be associated with bilateral total disc displacement. Bilateral deep masseter tenderness was also significantly associated with bilateral total disc displacement, occurring 6.81 times more frequently with bilateral disc displacement than with the other two groups of disc position.

Subjective reports of clinical symptoms were poorly associated with the MRI-determined disc position. Only a subjective history of TMJ sounds was entered into this logistic regression equation. The reported presence of TMJ sounds was 3.46 times more common in individuals with bilateral total disc displacement than any other group of disc position. Only 2 of the female subjects with bilateral total disc displacement as determined by MRI were unaware of joint sounds and did not report a history of joint sounds. No clinical variables related to the occlusion could be shown to be associated with the present grouping of MRI-determined disc position of the joints, and could therefore not contribute to the final regression model.

In the final ordinal logistic regression model, deep masseter and subjective history of TMJ sounds were included as significant variables in the model to explain the relationship between MRI-determined TMJ grouping and clinical signs and symptoms. Odds ratio calculations show that the chance of a subject responding to deep masseter palpation on the right-hand-side (denoted by subscript 2) was 38.87 times more likely to occur in a subject with bilateral total disc displacement, compared to the other groupings of MRI-determined TMJ disc position. In addition to muscle tenderness, a history of subjective TMJ sounds is 3.37 times more likely to occur in subjects with bilateral total disc displacement, compared to the other groupings of MRI-determined disc position.

The results of this study show that clinical signs and symptoms studied independently or in groups may be significantly associated with MRI-determined internal derangement. When these clinical variables are however combined into a regression model which draws only the most significant variables, far fewer clinical variables are seen to be significantly associated with disc position. This model of investigating clinical signs and symptoms related to disc position may serve as the basis for further investigation of larger samples.

From this study it appears that bilateral internal derangement of the TMJ in the adolescent sample may be related to bilateral, unilateral or even absent clinical signs and symptoms. This study once again emphasizes the varied presentation of clinical signs and symptoms associated with a known disorder such as MRI determined disc displacement[3]. Disc displacement associated with TMJ dysfunction may produce compensatory muscle contraction on both the ipsilateral and contralateral side to the disc displacement.

Depending on the duration, magnitude and extent of the muscle contractions, pain may be experienced in various masticatory or cervical muscles which may be difficult to correlate with internal derangement.

## 10.6 Conclusions

Clinical signs and symptoms associated with specific anatomic regions and subjectively reported symptoms were investigated by making use of a logistic regression model in a female adolescent sample. Occlusal variables were shown not to be significantly associated with MRI-determined disc position. A single subjectively reported symptom of TMJ sounds was entered into the final logistic regression model along with tenderness of the deep masseter to palpation. These clinical signs and symptoms seem to be most important in assisting the clinician in making a diagnosis regarding TMJ disc position. Signs and symptoms associated with TMJ dysfunction were significant in the TMJ model established but were not entered into the final regression model.

## 10.7 References

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## CHAPTER 11

# CLINICAL SIGNS AND SYMPTOMS IN AN ADOLESCENT POPULATION: A MULTIVARIATE ANALYSIS

### 11.1 Introduction

It is generally accepted that Craniomandibular disorders (CMD) are a group of disorders each with different etiologies and clinical signs and symptoms[1]. To suggest that all of these disorders have a common cause or a common treatment is beyond reason. Therefore it is essential that the clinician has suitable diagnostic criteria to allow for accurate reproducible diagnosis of disorders in order that the patient may be treated efficiently and successfully.

Clinicians rely on subjective clinical information obtained from joint and muscle palpation, assessment of mandibular range of motion, and symptoms reported by the patient. Interpretation of this information to identify a specific disorder without specific criteria to make a diagnosis of the disorder is problematic and lessens the chance of achieving treatment success. An accurate diagnosis is the first step in treatment of any disorder and should identify and classify the disorder correctly[2].

Epidemiological studies have investigated the prevalence of clinically defined signs and symptoms[3-6]. Other studies have examined the associations between clinically identifiable signs and presenting symptoms[3,5-11]. Furthermore, studies have attempted to determine associations between specific diagnosed disorders and presenting signs and symptoms[12-15]. Identification of specific signs and symptoms that may be related to a clearly defined disorder greatly aid in diagnosis, treatment planning and determining the prognosis of the disorder.

Previous studies have examined the associations between internal derangement and clinical signs and symptoms[13,16]. Lieberman *et al*[16] reported on the prevalence of clinical signs and symptoms in a small sample of adolescent individuals (32 preorthodontic patients), and showed that magnetic resonance imaging (MRI) findings of disc displacement are positively associated with late joint sounds and palpable joint and muscle tenderness. Katzberg *et al*[13] studied an adult population (mean age 28.3 years) and found associations between MRI defined categories of disc displacement and clinical signs and symptoms. These studies make use of only three subjective categories to define disc position, namely normal, disc displacement with reduction, and disc displacement without reduction. The differentiation between these categories is gross and does not allow for evaluation of subtle slight displacements which cannot be considered normal. Nor does this form of categorization permit severe displacements, characterized by loss of discal morphology, to be differentiated from displaced discs with relatively normal morphology.

The purpose of this study was to evaluate which signs and symptoms are most likely to be associated with progressive disc displacement, loss of discal morphology and loss of disc function as identified by MRI and determined by quantification of disc status.

## 11.2 Methods and Materials

One hundred and ninety four adolescents (75 males and 119 females) between the ages of 10 and 17 years were recruited for a study to examine temporomandibular joint status. Joint status was evaluated by means of a clinical evaluation, history and MRI investigation of disc status. All consenting subjects were included in the study whether clinical signs and symptoms of temporomandibular dysfunction were present or not. Individuals previously diagnosed with juvenile rheumatoid arthritis were excluded from the study. The Joint Dentistry/ Pharmacy Human Ethics Committee approved the acquisition of radiographic, MRI and clinical information.

Fourteen subjects were excluded from the study due to poor MRI quality and motion artifacts. An additional 32 subjects were excluded due to incomplete history or clinical evaluation, resulting in a study sample of 148 adolescent individuals (59 males and 89 females).

A comprehensive clinical examination of the temporomandibular joints, muscles of mastication, cervical muscles, and occlusion was carried out by a single observer to determine the presence of clinical signs and symptoms. In addition a history was obtained from each patient and legal guardian concerning temporomandibular joint dysfunction. The signs and symptoms investigated were divided into four categories for descriptive purposes and are presented in Tables 11.1 to 11.4. The clinical signs and symptoms were evaluated as follows:

1. Signs of Temporomandibular Joint Dysfunction

   The quality and quantity of joint movement were assessed during the range of condylar translation and laterotrusive movements. Maximal mouth opening, protrusion and laterotrusive movements were evaluated together with accompanying signs of movement. Digital palpation was used to investigate signs of joint tenderness and determine the quality of condylar movement (limited translation, catching, or ratcheting). Stethoscopic investigation was used to determine the presence of joint sounds (clicking, grating, or popping)(Table 11.1).

2. Signs of Masticatory and Cervical Muscle Tenderness

   Bilateral digital palpation of masticatory, accessory masticatory, cervical and intra-oral muscles was carried out to elicit a response regarding tenderness of the muscles (Table 11.2). Tenderness was scored as being present (1), or absent (0).

3. Occlusal Assessment

   Static occlusal relationships assessed Angle molar relationship, linear measurements of incisal overjet and overbite measured with a millimeter scale (Table 11.3).

4. Clinical Symptom History

Report and history concerning symptoms of temporomandibular disorders, craniofacial pain, facial trauma and habits were noted (Table 11.4).

All quantitative measures were determined with a millimeter rule accurate to the nearest 0.5 mm, and recorded as continuous variables. All qualitative signs and symptoms were scored as either being present (1) or absent (0), and were recorded as nominal variables for each joint.

Quantitative and qualitative variables used to determine signs and symptoms were divided into the four categories of interest and entered into four multivariate statistical models to determine whether these variables could be used to explain the variability in MRI determined TMJ disc length and disc displacement.

| **Variable** | **Score** | **Description** |
|---|---|---|
| Reproducible sound | nominal | Repeatable joint sounds audible with stethoscope on mouth opening or closing |
| Non-reproducible sounds | nominal | Intermittent joint sounds audible with stethoscope on mouth opening or closing |
| Early open click | nominal | Early opening click detected with stethoscope |
| Early close click | nominal | Early closing click detected with stethoscope |
| Mid-open/close click | nominal | Mid-range click detected with stethoscope |
| Late open click | nominal | Late opening click detected with stethoscope |
| Late close click | nominal | Late closing click detected with stethoscope |
| Lateral capsular pain | nominal | Pain perceived on light digital palpation of lateral capsular structures |
| Posterior capsular pain | nominal | Pain perceived on light digital palpation of posterior capsular structures |

| | | |
|---|---|---|
| Superior capsular pain | nominal | Pain perceived on light digital palpation of superior capsular structures |
| Crepitus | nominal | Audible grinding sounds with stethoscope |
| Deviation | nominal | Deviation of mandibular midline relative to maxillary midline greater than 2 mm on mouth opening |
| Unassisted opening | continuous | Vertical mouth opening including overbite measurement |
| Assisted opening | continuous | Assisted digital pressure for vertical mouth opening including overbite measurement |
| Right laterotrusion | continuous | Maximal right shift of mandibular dental midline relative to maxillary dental midline on laterotrusion |
| Left laterotrusion | continuous | Maximal left shift of mandibular dental midline relative to maxillary dental midline on laterotrusion |
| Protrusion | continuous | Maximal anterior sagittal movement of lower central incisor relative to upper including overjet measurement |
| Unassisted opening pain | nominal | TMJ pain experienced on maximal passive mouth opening |
| Assisted opening pain | nominal | TMJ pain experienced on maximal assisted stretched mouth opening |
| Left laterotrusion pain | nominal | TMJ pain experienced in either joint on maximal left laterotrusion |
| Right laterotrusion pain | nominal | TMJ pain experienced in either joint on maximal right laterotrusion |
| Protrusive pain | nominal | Pain experienced in either joint on protrusion |

*nominal score : 0 = no abnormality detected; 1 = abnormality present

Table 11.1: Signs of Temporomandibular Joint Dysfunction

| Variable | Score | Description |
|---|---|---|
| Temporalis | nominal | Tenderness on digital palpation of anterior, middle and posterior bellies |
| Temporalis insertion (intra-oral) | nominal | Tenderness on digital palpation |
| Masseter | nominal | Tenderness on digital palpation of anterior, deep and inferior regions of muscle |
| Medial pterygoid (extra-oral) | nominal | Tenderness on digital palpation |
| Medial pterygoid (intra-oral) | nominal | Tenderness on digital palpation |
| Lateral pterygoid (intra-oral) | nominal | Tenderness on digital palpation |
| Posterior digastric | nominal | Tenderness on digital palpation |
| Vertex | nominal | Tenderness on digital palpation |
| Sternocleidomastoid | nominal | Tenderness on digital palpation of superior, middle and inferior regions of muscles |
| Trapezius | nominal | Tenderness on digital palpation of insertion and origin |

*nominal score : 0 = no abnormality detected; 1 = abnormality present

Table 11.2: Signs of Masticatory and Cervical Muscle Tenderness

| Variable | Score | Description |
|---|---|---|
| Anterior attrition | nominal | Clinically detected excessive wear on 3-3 |
| Posterior attrition | nominal | Clinically detected excessive wear on teeth distal to 3's |
| Overjet | continuous | Measure of horizontal distance between labial of lower central incisor to labial of upper central incisal edge |
| Overbite | continuous | Vertical overlap of upper incisor over lower incisor |
| Anterior RCP/ICP discrepancy | nominal | Anterior shift greater than 1 mm from retruded contact to intercuspal contact position |
| Vertical RCP/ICP discrepancy | nominal | Vertical shift greater than 1 mm from retruded contact to intercuspal contact position |
| Lateral RCP/ICP discrepancy | nominal | Lateral shift greater than 1 mm from retruded contact to intercuspal contact position |
| Molar relations | nominal | Intra-oral evaluation of angle molar relationship,<br>Class II = (0), Class I = (1), Class III = (2) |

*nominal score : 0 = no abnormality detected; 1 = abnormality present

*continuous score: millimetre measurements, measured to 0.5 mm accuracy.

Table 11.3: Occlusal Assessment

| Variable | Score | Description |
|---|---|---|
| TMJ pain history | nominal | Subjective appreciation of present/ previous TMJ pain |
| TMJ sounds history | nominal | Subjective appreciation of present/ previous TMJ sounds |
| Headache history | nominal | History of recurrent headaches, more than 1/week |
| Neck pain history | nominal | Subjective appreciation of neck stiffness or tenderness which is persistent |
| Joint locking history | nominal | Previous or current open or closed joint lock |
| Mouth-breathing | nominal | Nocturnal/ diurnal history of mouth-breathing |
| Tonsillectomy | nominal | History of recurrent tonsillitis or tonsillectomy |
| Thumbsucking | nominal | Present/ previous history of thumb/ finger sucking |
| Facial trauma | nominal | History of trauma involving maxilla or mandible |
| Birth trauma | nominal | History of birth trauma or severe illness |
| Bruxism | nominal | Subjective appreciation of nocturnal/ diurnal para-functional habits |
| Earache history | nominal | History of recurrent earaches |
| Ear infection history | nominal | history of recurrent ear infections or ear drainage |

*nominal score : 0 = no abnormality detected; 1 = abnormality present

** history was obtained in consultation with subject and guardian

Table 11.4: Clinical Symptom History

MRI determined variables were obtained by making use of a 1.0 Tesla magnet (Shimadzu Corporation, Tokyo, Japan) and a unilateral 3 inch surface receiver coil. Bilateral MRIs of the TMJs were obtained once axial localizing scans in the regions of the joints located the long axes of the condyles. The subsequent coronal and sagittal images produced were

T1-weighted 500/20 (TR ms/ TE ms) with a 3 mm slice thickness, 140 mm field of view, NEX of 2, and an image matrix of 204 x 204. Closed mouth sagittal and coronal images were produced making use of a polyvinylsiloxane (President Jet-Bite, Coltene/ Whaledent Inc. Mahwah, NJ) centric occlusion bite registration. Bilateral closed-mouth sagittal images were produced perpendicular to the condylar long axis, while coronal images were obtained parallel to the condylar long axis. Bilateral open mouth sagittal images were produced making use of a Burnett caliper (Medrad, Pittsburgh, PA) set at 10 mm below the maximal voluntary interincisal mouth opening.

All sagittal closed-mouth MRI slices of the joint were traced by a single examiner to identify the osseous articular structures and the articular disc. This resulted in 3 to 6 tracings per joint, corresponding to the number of MRI slices. The long axis of the condylar neck was identified on the most representative central slice per joint. This was used to transfer reference planes from corresponding lateral cephalometric radiographs to the MRI tracings according to previously described techniques[17]. The reference planes, and in particular the eminence reference plane facilitated measurement of disc length and disc displacement on each sagittal MRI slice. In this study the MRI determined TMJ measurements was employed as the dependent variables in multivariate analyses. Most statistical packages are however unable to process data having more than one dependent variable, therefore a single dependent variable per joint had to be determined. Principal component analyses (SPSS for Windows, SPSS Inc, Chicago) were utilized to compute a single dependent variable per joint.

In a previous study a negative association between disc displacement (DD) and disc length (DL) measures were shown[17], that is, as DD measures increase, DL decreases. Therefore it was considered prudent to allow the two variables to proceed in the same relative direction. This was done by subtracting measurements of DL from what was considered to be normal disc length[17] (10.00 mm), to produce a reciprocal DL measurement for each joint slice. Thereafter, a principal component analysis was applied to produce a single reciprocal DL measure per joint. Principal component analysis was correspondingly applied to the DD measures from each slice to produce a single weighted DD score per joint. The weighted scores for DD and reciprocal DL could now be entered into the final principal component analysis to produce a single TMJ internal derangement dependent variable per joint. Left and right joints were regarded as independent units in this analysis.

## 11.3 Error of Method

Ten MRI's representative of normal disc position and ten representative of disc displacement were retraced five times each on consecutive days to determine intra-rater reliablility in measurement of disc length and disc displacement. Coefficients of intra-rater reliablility (Rel = 1-1/F)[18] for disc displacement and disc length were computed making use of F-statistics generated by multivariate ANOVA procedures. F-statistics measure the significance of between tracing variability, so 1-1/F will measure within tracing variability relative to total variability.

## 11.4 Statistical Analysis

Differences in measures of TMJ internal derangement score between males and females was tested making use of an independent sample t-test. Similarly differences in age between the genders was tested by making use of an independent t-test. Thereafter, a paired t-test was used to investigate side specific differences in the dependent variable (TMJ internal derangement score).

Multiple regression analyses were performed for each of the four categories of signs and symptoms identified. Stepwise Regression analyses were carried out separately for males and females since an independent t-test showed statistically significant differences in

TMJ internal derangement scores between the two groups. The MRI determined TMJ variable was entered as the dependent variable for both the right and left TMJ while the independent clinical variables were matched with side specific dependent variable data.

## 11.5 Results

Intra-rater reliability coefficients for disc displacement and disc length were computed to be 1.00 and 0.98 respectively. If total variability of either disc displacement or disc length in a sample may be regarded as 1, then the remaining variability for disc displacement (1-1 = 0) and for disc length (1- 0.98 = 0.02) is due to tracing error or intra-rater error. This error is small relative to total variability measured for variables and can be ignored.

Independent sample t-test of TMJ internal derangement scores between males and females showed significant differences between the two groups (p = 0.000), necessitating separate investigation of the groups. No difference in age was however detected between the male and female group making use of an independent t-test (p = 0.887), while a paired t-test for determination of left-right TMJ internal derangement measure differences revealed no side specific differences (p = 0.966). Since no side specific differences were noted in the presentation of MRI determined disc displacement, both left and right joints were entered into the regression models as independent joints.

The independent variables which contributed to explaining the variability in the dependent variable for each of the four multiple regression analyses are listed in Tables 11.5 and 11.6 for females and males respectively. A final model was constructed making use of significant variables from each of the 4 regression analyses for males and females. The computed level of significance for each independent variable, correlation coefficients between the dependent and independent variable, and the adjusted R-square for each regression equation are presented.

Pearson correlation coefficients were computed for variables included in each equation relative to variables excluded from the equations to determine if variables were removed from the regression equations due to high correlation. In both the male and female sample, no variables already not included in any of the regression equations were found to be highly correlated (0.80) with variables included in the equation. Therefore, the results indicate all variables which potentially contributed to explaining the variability in the dependent variable were included in the models.

| Category | Independent Variable | Significance | Correlation Coefficient | Adjusted $R^2$ |
|---|---|---|---|---|
| **Temporomandibular Joint** | Repro. open sounds | 0.0008 | +0.3342 | 0.269 |
| | Lat. caps. tender. | 0.0128 | +0.1989 | |
| | Pain on assist. open | 0.0218 | -0.1363 | |
| | Deviation on open | 0.0025 | +0.3527 | |
| **Masticatory and Cervical Muscles** | Mid. Temporalis | 0.0159 | +0.0217 | 0.190 |
| | Post Temporalis | 0.0327 | -0.0875 | |
| | Deep Masseter | 0.0183 | +0.2167 | |
| | Medial Pterygoid | 0.0012 | +0.2172 | |
| **Occlusal Assessment** | Overbite | 0.0085 | -0.2912 | 0.084 |
| **Subjective History** | - | n.s. | - | - |
| **Final Female Model** | Repro. open sounds | 0.0017 | +0.3342 | 0.284 |
| | Overbite | 0.0011 | -0.2912 | |
| | Deviation on open | 0.0006 | +0.3527 | |

Table 11.5: Results of Multiple Regression Analyses for Females

| Category | Independent Variable | Significance | Correlation Coefficient | Adjusted $R^2$ |
|---|---|---|---|---|
| **Temporomandibular Joint** | Repro. open sounds | 0.0003 | +0.3905 | 0.216 |
| **Masticatory and Cervical Muscles** | Inf. Masseter | 0.0191 | +0.4278 | 0.0854 |
| **Occlusal Assessment** | - | n.s. | - | - |
| **Subjective History** | Headaches | 0.0040 | -0.0318 | 0.659 |
| | Facial Trauma | 0.0000 | +0.2025 | |
| **Final Male Model** | Repro. open sounds | 0.0009 | +0.3905 | 0.255 |
| | Inf. Masseter | 0.0026 | +0.4278 | |

Table 11.6: Results of Multiple Regression Analyses for Males

## 11.6 Discussion

Multiple regression analyses were performed for the female and male sample separately, including only signs and symptoms from one of the four groups specified. The contribution of the independent variables to explaining the variability in the dependent variable was considered for each of the four groups of variables for each gender.

### Symptoms of Temporomandibular Joint Dysfunction

In the female model, deviation in mouth opening to the affected side was noted together with lateral capsular tenderness on palpation. The deviation may have been as a result of mechanical interference to condylar translation by the displaced disc while the capsular tenderness could have been due to inflammation of the retrodiscal tissues.

Assisted opening pain and reproducible opening joint sounds were entered into the model and contributed towards explaining the variability in the dependent variable. The overall contribution made by the independent variables in the female model was rather low with an adjusted R-square of only 0.269. In a study examining the signs and symptoms of temporomandibular joint dysfunction in Israeli schoolchildren, Gazit *et al*[6] cautioned that the occurrence of joint sounds together with joint sensitivity may be an indicator of joint pathology. This seems to be the case in the female sample, since both joint sounds and sensitivity to palpation were entered as variables which could aid in explaining the variability in TMJ disc displacement.

In the male group only one variable remained within the regression equation, namely reproducible opening joint sounds. This variable contributed substantially to explaining the variability in the dependent variable (adjusted R-square = 0.216). It is interesting to note that capsular tenderness and deviation on opening were not features in the male regression model. In both models reproducible joint sounds were represented as significant variables in the respective equations. Previous studies have cautioned that the presence or absence of joint sounds should not be used to determine disc position[10,19,20]. This view is supported by this study in light of the low correlations achieved between MRI determined disc status and clinically detectable joint sounds. It should be appreciated that in instances of disc displacement without reduction no joint sounds may be present even though the disc is totally displaced and the patient is asymptomatic[21,22].

### Masticatory and Cervical Muscle Tendernesss

The regression equations considering palpable muscle tenderness were significantly different for males and females. Palpable tenderness of the inferior masseter muscle was the only muscle entered into the regression equation in the male sample. The adjusted R-square was correspondingly low at 0.085.

By contrast, in the female sample four regions of palpable muscle tenderness were entered into the equation and the adjusted R-square for the equation was significantly higher at 0.1896. For females, the mid temporalis and posterior temporalis were entered into the equation but the correlation coefficients for these muscles were notably small or negative, indicating a lack of association between the temporalis musculature and MRI determined disc status. A positive finding on palpation of the deep masseter muscle (r = 0.217) and medial pterygoid (r = 0.217) contributed the most to explaining the variability in MRI determined internal derangement in the female model.

Gazit *et al*[6] recorded muscle sensitivity in 20.3% of 10 - 18 year old schoolchildren, while Mohlin *et al*[23] reported masticatory muscle tenderness to occur in 27% of 12-year-olds studied. The lateral pterygoid muscles were the most frequently tender followed by the masseter muscles[23]. In the present study the lateral pterygoid was not a significant factor in explaining the variability in TMJ internal derangement. Interpretation of findings of muscle palpation are extremely difficult due to the lack of standardization of technique, patient's previous experiences and cultural background[24]. To complicate matters, the significance of muscle tenderness, and the interpretation of these findings in an adolescent sample are still unclear.

### Occlusal Assessment

In a previous study on adolescent individuals a positive association was shown between joint tenderness and increased or decreased overjet and reduced overbite[11]. Associations between joint tenderness and a Class II molar relationship were shown but were dependent on age and gender of the individual[11]. In a study by Keeling *et al*[10], no associations between joint sounds and age, gender, race, or molar class were shown in

3428 grade school-children. This study did however show associations between joint sounds and maxillary and mandibular anterior dental crowding, increased maximal opening, and deeper overbites[10]. These contradictory findings illustrate the difficulties in interpreting the literature when clinical signs and symptoms are used to establish a diagnosis and emphasize the need for specific diagnostic criteria such as TMJ disc status to be tested.

In the present study, no occlusal features were entered into the male regression model. In the female equation, TMJ internal derangement was negatively associated with overbite. That is, as the degree of internal derangment of the TMJs increases the amount of incisal overbite decreases. This single variable produced an adjusted R-square of 0.0842.

### Clinical Symptom History

In the male regression equation only a history of facial trauma was found to be positively associated with TMJ internal derangement. Headaches were entered into the regression equation but were negatively associated with TMJ internal derangement. Therefore the inclusion of headaches as a subjective symptom is difficult to explain and may have nothing to do with disc position in the TMJ. The adjusted R-square for the two variables entered into the male model was however high at 0.659. This means that approximately 66% of TMJ disc position status may be explained by these two variables in the absence of other clinical information. It should be emphasized that a history of headaches, facial trauma and other related symptoms should be interpreted with caution. These reported symptoms tend to be over- or under-reported with the progress of time and may not be reliable indicators of the present status of the joint.

No variables were entered into the female regression equation, none were significant in explaining the variability of TMJ internal derangement.

**Final Regression Models**

A single model was created for males and females by combining significant variables from each region to produce a simplified model for predictive purposes. In the female model, three variables remained in the model and were ranked in order of importance in explaining the variability in the dependent variable. Variables were ranked according to the p-values generated by the regression equation. Variables ranked in order of significance in the final female model were therefore: deviation on mouth opening; reduced incisal overbite; and reproducible opening sounds within the TMJ. The adjusted R-squared for the female model was 0.284. In the male model only reproducible opening joint sounds and inferior masseter muscle tenderness to palpation remained in the model. The adjusted R-squared for the male model was only 0.255.

From the above final models it can be shown that the predictive ability of clinical signs and symptoms is poor when clinical variables are combined into a single model. In both final models the clinical variables explain less than 30% of the variability of TMJ disc position. This means that over 60% of the information needed to predict disc position was not available and that by using only clinical variables in a combined model as shown here, disc position can be predicted with less than 30% accuracy.

As with any clinical investigation this study had design limitations which may influence the results achieved. The design limitations of this study were as follows:

- intra-rater reliability in assessing clinical signs was not tested,
- a larger sample of adolescent individuals may improve the results of this study,
- an adolescent sample was studied with varying levels of maturity and responsiveness to clinical evaluation,
- adolescents may be subclinical due to great adaptive capacity of the TMJ and craniofacial region even though disc displacement is present. Signs and symptoms may only develop later in life.

The fact that approximately 30% of individuals with disc displacement are asymptomatic also needs to be considered when a model for determining the significance of clinical signs and symptoms is designed.

## 11.7 Conclusions

Associations between clinical signs and symptoms and quantifiable MRI determined disc status were shown in the present study. The magnitude of the associations were too small to be used for predictive purposes instead of MRI determined TMJ disc information.

Further studies are needed with matched control and symptomatic groups in both the adult and adolescent population to test quantifiable disc status as well as other quantifiable measures of muscle, joint and occlusal characteristics to determine which clinical signs and symptoms are most likely to be associated with craniomandibular disorders. Asymptomatic disc displacement also needs further investigation to understand the duration and temporal significance of the observation.

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# CHAPTER 12

# General Discussion

## 12.1 Introduction

The main aim of this study was to investigate the relationship between TMJ disc position and adolescent craniofacial morphology. Craniofacial morphology was readily investigated making use of conventional cephalometric radiography and cephalometric measurements of the various facial regions of interest. Direct determination of disc position and disc status was achieved utilizing MRI of the TMJ. Methods for quantification of disc position were however found to be deficient and based on subjective interpretation of disc position instead of objective criteria. Therefore a quantitative assessment protocol for disc position was developed and tested for intra- and inter-rater reliability.

The second objective of this study was to determine if a clinical evaluation of the TMJ and a history of TMJ symptoms could be used to determine the status of the articular disc. Clinical signs and symptoms are readily obtained and are less expensive for diagnosis of joint disorders than the more expensive MRI techniques. The presentation of clinical signs and symptoms were investigated to determine if they are adequate indicators of joint disorders and disc position.

This discussion serves to highlight the results achieved for each of the stated objectives. The findings of the present study will be discussed and reference will be made to the strengths and limitations of the study. The strengths and limitations of the present study will also be examined to determine how these may contribute to future studies. Furthermore, advances made through the course of this study will be evaluated in order to determine their impact on clinical assessment and treatment and their influence on future investigations.

## 12.2 Results of the Present Study

The feasibility of a comprehensive evaluation of craniofacial morphology and disc position was tested by a pilot study. The pilot study comprised 25 pre-orthodontic adolescent individuals (males and females) with and without signs and symptoms of TMD who were age and sex matched to population norms for cephalometric measurements presented in the Craniofacial Growth Series[1]. MRI disc position was evaluated in accordance with the principles of Drace and Enzmann[2] which specify that the angular displacement of the posterior band of the disc is measured from the 12 o'clock position of the condyle.

The results of this study showed that angular disc displacement was positively associated with an increased palatal plane angle, mandibular plane angle relative to sella-nasion and increased maxillary antero-posterior dimension relative to published norms. In addition, angular disc displacement was negatively associated with ramus and total posterior facial height and upper molar to palatal plane height, compared to norms. Limitations of sample size however necessitated the use of population norms which may not have matched the pilot sample in terms of ethnic origins and maturity status. Furthermore, the MRI evaluation method was inadequate as it used only one MRI slice out of the 4 to 6 slices per joint available and relied on a 12 o'clock reference position which could not be standardized by head positioning in the imaging magnet.

The lack of standardization of head position with MR imaging, in addition to the bias introduced with MRI slice selection per joint, resulted in a search for a more reliable method for quantification of disc position. A literature review revealed that only subjective classification of disc position was being used as the standard method for joint evaluation[3]. This subjective categorization cannot provide quantification of disc position or a continuum of measurements describing disc position and at best provides only categorical data.

Therefore a new technique for quantification of disc status was developed in the process of this study, based on the functional position of the disc with the teeth in maximal intercuspation. Reference planes were obtained from lateral cephalometric radiographs and transferred to sagittal MRI slices of the TMJ. These reference planes were tested for reproducibility and used to standardize disc measurements. Variables describing disc length and disc displacement were determined by measurement of disc structures relative to the eminence reference plane and the load point on the anterior surface of the condyle. Measurements of disc displacement, disc length and the ratio of disc displacement to disc length were entered into a discriminant analysis to determine if the TMJ variables identified (namely disc length, disc displacement and ratio) could be used to classify joints into 5 categories of disc position, according to a subjective evaluation by a maxillofacial dental radiologist. Using this discriminant function and quantification technique, it was possible to correctly assign disc position to one of five categories of disc status approximately 70% of the time when an experienced radiologists' subjective criteria were taken as the standard for comparison.

This technique showed that measurements of disc displacement and disc length can be used to quantify the soft tissue status of the joint. The described technique is an improvement over conventional disc classification methods for the following reasons:

- It allows for standardization of measurements and determination of disc position by establishing reproducible reference planes,
- The study allows all sagittal MRI slices of the joint to be considered in the evaluation of disc status,
- It provides a continuum of quantifiable data that can be used for statistical evaluation.

Furthermore, the results of this study show that as the subjective category of disc displacement increases in severity, the measure of sagittal disc displacement increases, and the overall sagittal length of the disc decreases. This is the first study to quantify the relationship between disc displacement and reduction in disc length. These findings will significantly assist future investigations to determine the osseous articular surface area covered and protected by the articular disc, and may improve our understanding of the pathophysiology of disc displacement as it relates to load and fluid distribution of the articular disc.

This quantification technique could however not be validated on post-mortem specimens due to the lack of availability of specimens and corresponding MRIs of these specimens. It is hoped that a post-mortem sample will be available in the near future for validation and three-dimensional reconstruction of MR images of the joint which will allow the extent of altered disc status to be fully appreciated.

Interobserver reliability in subjective evaluation of disc position and inter-rater reliability in the application of the quantification technique were however tested to determine the reproducibility and measurement error of the technique.

The consistency of subjective interpretation of disc position was tested across four examiners experienced in interpretation of MRIs of the TMJ. Interobserver reliability evaluation was an essential consideration since the discriminant analysis of disc position relied on the subjective classification of disc position into six categories. Interobserver agreement in classification of disc position was assessed using Kappa statistics[4,5]. The same statistics were also generated for each individual category of disc position. This study confirmed that in the interpretation of MR images of the TMJ, moderate to substantial observer agreement can be achieved amongst experienced observers applying standardized classification criteria. Individual observers were confident in identification of normal disc position and discs that were displaced with and without reduction on open-mouth images. Variability between observers occurred mostly in the intermediate stages (slight and moderate disc displacement) as defined by the classification criteria established in chapter 3. The clinical and functional significance of moderate disc displacement and its progression to total disc displacement however needs further investigation.

In addition to determining the interobserver reliability in subjective evaluation of disc position, the interobserver reliability in application of the new technique for quantification of TMJ disc status on MRI was also investigated. As before, four examiners were employed to trace the outlines of the soft tissue articular disc and osseous articular structures on each sagittal MRI slice per joint. Quantitative measurements of disc length and disc displacement were produced for each slice traced by each observer and intraclass correlation coefficients (ICC)[6] were computed to assess inter-observer agreement in tracing joint structures. Variability amongst observers for measurement of disc displacement and disc length was calculated. Mean variability amongst observers for determination of disc length and disc displacement was less than 1 mm, while the (ICC) showed substantial to almost total agreement amongst observers.

Unlike previous studies that reported on the quantification of disc position[2,7] this study shows excellent interobserver agreement when our new quantification technique for determination of disc length and disc displacement is applied. Mean variability of less than 1 mm in measurements of disc status is of lesser magnitude than the ± $5^0$ inter- and intra-rater variability for angular disc displacement measurements claimed by Drace *et al*[2]. In addition this study avoids subjective interpretation of the 12 o'clock position relative to the condyle, by applying reproducible reference planes.

The studies conducted as part of this research design show that quantification of disc position is reproducible when standardized reference planes and measurement criteria are utilized. Furthermore, analysis of disc displacement and disc length provided additional information regarding disc status which can be used for further analysis to determine the relationship between disc status and adolescent craniofacial morphology. The bias introduced by MRI slice selection and the limitations of subjective interpretation were overcome by employing the new technique for quantification of disc status.

As part of a comprehensive evaluation of TMJ disc status, 194 pre-orthodontic adolescent individuals (75 males and 119 females) between the ages of 10 and 17 years were evaluated. The group consisted of subjects with and without clinically detectable TMJ signs and symptoms (capsular pain; joint sounds; masticatory muscle tenderness; limited mandibular range of motion; deviation on opening). No individuals with diagnosed juvenile rheumatoid arthritis were included in the study. Five males and nine females were excluded from further evaluation due to poor cephalometric quality or motion artifact on MR images which reduced their diagnostic quality.

The prevalence of disc displacement in the remaining study population (70 males and 110 females) was evaluated using the classification rule derived from the discriminant analysis technique for disc position. The prevalence of normal disc position in the male sample was calculated to be 52.9%, while that in the female sample was 26.6%. The prevalence of total disc displacement with or without reduction was found to be 10.9% for males and 30.4% for females with a combined percentage of 22.7%. The prevalence of the intermediate stages of disc displacement was similar in males and females and fairly equally distributed between the remaining two categories of disc position. Bilateral normal disc position was more prevalent in males (36.8%) than females (16.0%), but bilateral total disc displacement (disc displacement with or without reduction) was more prevalent in females (16.9%) than in males (1.5%). Disc displacement in one joint with contralateral normal disc position occurred with a frequency of (29.4%) in males and

(18.3%) in females. The prevalence of disc displacement in this study sample was similar to recently published data by Tasaki *et al*[3].

This study sample is not considered representative of the general population. Despite the prevalence of disc displacement corresponding well with previously published data[8,9], the sample was drawn from a population of individuals presenting for orthodontic consultation and may differ from the general population. This seems to be the case when the number of females versus males entered into the study is considered . Furthermore, the prevalence of normal disc position in females cannot be considered representative of the general population of adolescents. Literature reports on MRI-determined disc displacement in adolescents and young adults have ranged from 12%[8] to 25%[9], depending on the method used for disc position determination, ethnic background, and age of study sample. These studies are however limited by small sample size or non-random sample selection and should be interpreted with caution.

Through the course of this research a means of determining disc position was established and tested and a method for quantification of facial proportions was successfully applied in the pilot study. Prior to subjecting the data to multivariate statistical techniques to determine the associations between disc displacement and craniofacial morphology, it was considered prudent to test the collected cephalometric data to asses whether statistical and clinical differences could be identified between two groups with extremes in disc position. Cephalometric variables were compared between a group of individuals with normal disc position throughout both TMJs, and a group with bilateral total disc displacement throughout both joints.

In this study only two males presented with bilateral total disc displacement therefore no meaningful comparisons could be made for the male sample. In the female sample, 17 females presented with bilateral normal disc position and could be compared to 17 females with bilateral total disc displacement. It was determined that the effects of age and sex could be ignored since independent sample t-test showed no differences in age between the two groups of females evaluated. Independent t-test evaluations showed statistically significant differences in the mean cephalometric values between the two groups. These mean differences in cephalometric values were of sufficient magnitude to be considered clinically significant. Essentially the differences between the two groups showed that females with bilateral total disc displacement have a reduction in ramal and posterior facial height, a reduction in vertical dimensions of the posterior cranial base, an increase in the palatal plane and mandibular plane relative to midline cranial reference planes, and posterior rotation of the mandible, compared to the group with bilateral normal disc position.

These differences in facial pattern are dramatic but the significance of these findings must be considered with caution due to the small sample size. A larger sample meeting the criteria for inclusion needs to be assessed to validate the present findings. If there is an association between facial patterns and disc displacement, then similar facial patterns should be observed in a male sample with bilateral total disc displacement. Multivariate statistical techniques can however be utilized to test associations in the whole sample rather than determining differences between select groups, thus avoiding the sample size dilemma for between group comparisons. These multivariate procedures were employed to test associations between disc status and craniofacial morphology in the respective male and female samples.

In the male and female sample separate multiple regression analyses were performed to test the association between TMJ internal derangement, which was considered the dependent variable, and the independent cephalometric variables. Five separate regression equations were formed with cephalometric variables representing the various facial regions of interest in both the male and female sample. The dependent variable was determined by making use of a principal component analysis which produced a single weighted disc length and disc displacement score per joint. Since the effects were considered to be additive, the weighted scores for disc displacement and disc length from both joints were added and once again subjected to principal component analysis to produce a single TMJ dependent variable. This procedure was adopted since most statistical packages are unable to enter more than one dependent variable in multiple regression techniques.

The independent variables (lateral cephalometric variables) are age dependent. That is, the variable of interest increases in dimension with increasing age. This increase is however not linear due to the occurrence of a pubertal growth spurt, which is evident in the sample under investigation. It was therefore important to control for the effect of age and to include polynomial terms for each cephalometric variable to explain the second order curves produced by the pubertal growth spurt. These transformations may have increased the complexity of the analyses but greatly enhanced the ability of the evaluation to determine meaningful associations where present. Without the incorporation of polynomial terms the secondary curves of the non-linear data could not be adequately explained.

In both the male and the female sample separate multiple regression analyses identified similar patterns of variables entered into the equations, when the position of the mandible and mandibular morphology was assessed. In summary, in both groups of adolescents the mandible showed a reduction in posterior vertical dimensions, a reduction in sagittal dimensions, an increased flexure between the ramus and corpus as interpreted by increased Ar-Go-Me angular measurement, an increase in the mandibular plane angle and an increase in total anterior facial height associated with increased measures of internal derangement.

Similar variables were significant in the regression equations describing the position of the dentition in males and females with the exception of measurements of maxillary posterior vertical dental height, which was significant in the female regression equation only. These results were difficult to interpret since the error in measurement of these variables was considered to be excessive. The variability in measurement technique for these variables could have explained the variability in the dependent variable instead of the variability of the sample population contributing to explaining the variability of the dependent variable.

For the remaining two facial regions, differences in the expression of variables in the regression equations were noted between the male and female sample. In the cranial base region only females expressed a decrease in sagittal cranial base dimensions and decreased flexure of the cranial base associated with increased degrees of internal derangement. In the male sample this association was not evident. However, in both the male and female sample a reduction in posterior vertical cranial base dimensions was associated with an increase in internal derangement of the TMJ.

Gender differences were also evident in the inclusion of significant variables used to describe the maxillary position. In the male regression equation only one variable was included as significant and could not be used to determine the position of the maxilla since it expressed the relationship between the maxilla and mandible. Since mandibular position was shown to be altered, a change in the relationship between the maxilla and mandible may be due to the altered position of the mandible instead of a positional change in the maxilla. In the female regression equation, the cant of the palatal plane relative to cranial base structures and the posterior vertical dental height were entered as significant variables and explained the variability in the dependent variable. These variables showed a reduction in posterior maxillary dental height and an increased cant of the palatal plane with increased severity of internal derangement, but did not show alterations in either the vertical or sagittal dimensions of the maxilla.

The results of the pilot study, independent sample t-test and multiple regression analyses show that associations do occur between internal derangement and facial morphology. The associations are strongest and most consistent in the mandibular region and describe sagittal, vertical and positional changes of the mandible. The superior component of the TMJ articulation also shows consistent alterations in vertical dimensions associated with internal derangement. Furthermore the overall facial pattern associated with internal derangement is not gender-specific despite differences between the groups being identified.

The association between internal derangement and alterations in facial morphology should not be interpreted as a cause and effect relationship. Similar alterations in facial patterns but more severe in nature have been noted in cases of juvenile rheumatoid arthritis affecting the TMJ[10,11] and in cases of condylar hypoplasia[12]. Furthermore, similar facial patterns have been reported in a study which evaluated the presence of radiographic changes ascribed to the process of osteoarthrosis affecting the joints in adolescent individuals[13,14]. Internal derangement may be a consequence of abnormal biomechanical function associated with altered craniofacial morphology, or may occur due to some unidentified factor. Since the effect of duration of disc displacement has not been determined by this cross-sectional evaluation, no explanation regarding growth alteration, from this study, can be made. Longitudinal evaluation of growing individuals may give an indication of the extent of facial changes occurring in individuals with internal derangement, no cause and effect may be claimed until all factors influencing growth are more thoroughly investigated. A longitudinal investigation may contribute to our understanding of the patterns of internal derangement most prone to progress to total disc displacement with associated development of craniofacial pain and dysfunction.

Associations between internal derangement involving the TMJ and craniofacial features in an adolescent population are of considerable importance to the clinician. The practitioner identifying these facial features in pre-orthodontic individuals may be prompted to investigate the status of the TMJ to determine the effects of internal derangement on further facial development, and what effect disc displacement has on the treatment prognosis. Using MRI to confirm a diagnosis of internal derangement can however prove to be problematic, since MRI is not universally available, is expensive and increases the cost of providing health care. This prompted us to investigate the most readily available and inexpensive diagnostic information, namely clinical signs and symptoms. If patterns of clinical signs and symptoms were positively associated with MRI findings of internal derangement, then these signs and symptoms could potentially increase the clinician's diagnostic accuracy, thereby reducing the reliance on MR imaging.

The aim of the first clinical study was to determine whether significant differences in presenting signs and symptoms occurred in adolescent individuals with extremes in MRI diagnosis of disc position. Once again males were excluded since the male group only had 2 subjects with bilateral total disc displacement. Further analysis was carried out on only the female sample. This study attempted to determine associations between clinical signs and symptoms and MRI-determined disc position making use of logistic regression procedures. Clinical signs and symptoms were divided into 3 categories based on anatomical divisions, a fourth category was used to determine the significance of subjectively reported clinical symptoms. Discriminant analysis categories of MRI-determined disc position were used to establish 3 groups based on the bilateral status of the disc in the joints. The 3 groups identified were: bilateral total disc displacement, bilateral normal disc position, and inconsistent disc position throughout the joint on one or both sides, or disc displacement on one side and not the other. Odds ratios[15] were computed to determine the likelihood of a clinical sign or symptom being associated with bilateral total disc displacement, compared to the other two groups of disc position.

The results of this study show that deep masseter tenderness to palpation and a history of TMJ sounds were more prevalent in females with bilateral total disc displacement than in females with bilateral normal disc position or in females with inconsistent disc position within the joints and inconsistent disc position between the joints. The odds ratio showed that the chance of having right-sided deep masseter tenderness was 38.7 times greater with bilateral total disc displacement, compared to other groups of bilateral disc position. As far as subjective symptoms were concerned, a TMJ sounds were significantly more common in individuals with bilateral total disc displacement, compared to individuals with normal disc position or bilateral inconsistent disc displacement.

In a further analysis of clinical signs and symptoms, these clinical variables were subjected to multivariate statistical tests to determine if a model could be established that would help in predicting the position of the articular disc. As before, the clinical information was divided into four categories representative of symptoms associated with TMJ dysfunction, symptoms of masticatory and cervical muscle tenderness, static occlusal assessment and recorded subjective symptoms. In this model the dependent variable was the quantitative measure of both disc displacement and disc length as defined by the principal component procedure. Males and females were investigated separately since the results of an independent t-test showed that a significant difference in mean TMJ internal derangement scores occurred between males and females. No mean age difference was evident between the genders and paired t-test could not identify side-specific differences in TMJ internal derangement scores within either gender.

The results of the study show that reproducible opening joint sounds are consistently represented in both the male and female regression analyses established to describe TMJ dysfunction signs and symptoms. In addition to joint sounds, lateral capsular tenderness to palpation was entered into the female model together with mandibular deviation to the affected side and pain within the TMJs on assisted opening. Previous studies have however reported poor diagnostic sensitivity of joint sounds and the occurrence of false-positive and false-negative findings when joint sounds are used to diagnose disc position[16,17]. This view is supported by the present study in light of the low correlations achieved between MRI determined disc status and clinically detectable joint sounds.

The interpretation of the results for the masticatory and cervical musculature regression equation in males was rather insignificant with only one muscle contributing to explaining the variability in the TMJ dependent variable. Tenderness to palpation of inferior masseter explained 8.5% of the variability of the dependent variable. In the female muscle regression model four palpable muscle regions within three muscles were entered but only tenderness in the deep masseter and medial pterygoid contributed significantly to the model, the other two muscle regions (posterior and mid temporalis) had very weak correlations (less than 10%).

In the female regression equation a reduction in anterior incisal overbite contributed to explaining the variability in the TMJ dependent variable when only occlusal features were investigated. No variables were entered into the corresponding regression analysis carried out on the male clinical data.

Regression equations established for recorded subjective history showed no associations between reported symptoms and TMJ internal derangement in the female sample. In the male model a history of facial trauma was entered. In addition a history of headaches was entered but was negatively associated with increased degrees of MRI-determined disc displacement. This finding was difficult to interpret and suggests that individuals with normal disc position are more prone to have headaches than individuals with disc displacement. It should be emphasized that a clinical history tends to be over- or under-reported with the progress of time and may not be a reliable indicator of the present status of the joint.

A final regression model was established for males and females to determine the predictive power of clinical variables in identifying disc displacement. In the male model only 2 clinical variables remained significantly associated with TMJ disc position. These variables were reproducible open joint sounds and tenderness to palpation of the inferior masseter. These two variables contributed 25.5% to explaining the variability in the dependent variable. In the female model, the following variables were entered: reproducible open joint sounds, deviation of mandibular opening and a reduction of incisal overbite associated with increased degrees of internal derangement. The variables entered into this model contributed 28.4% to explaining the variability in TMJ internal derangement measurements.

The results of this study support previous studies[18,19] in showing poor associations between clinically determined signs and symptoms as indicators of internal derangement. Even though joint sounds were significant variables in these regression, their contributions were small and the limitations of interpretation of joint sounds in larger samples should be kept in mind[16].

## 12.3 Strengths and Limitations of the Study

All investigations suffer from limitations and deficiencies, this study makes no exception. It is hoped that the contributions made by this study may assist in advancing our knowledge of the TMJ and its associations with facial morphology in adolescents. Certain features of the study have emerged as distinct strengths which could be transferable to future investigations. These strengths have been mentioned in the discussion but will be highlighted again to emphasize their contribution.

- A method of quantification of MRI-determined disc status has been developed. The researcher and clinician no longer needs to rely on a subjective interpretation of MRIs of the TMJ.

- The quantification of disc position can be standardized using reproducible reference planes,
- All MRI sagittal slice information may be utilized to determine disc position, instead of single slice selection,
- Interobserver reliability in the application of the quantitative technique was tested by a number of observers with different training and backgrounds, and proved to be reproducible when applied to both normal and displaced discs,
- A significant contribution was made to understanding disc displacement by determining the relationship between disc displacement and articular disc shortening in cases of internal derangement,
- Individuals included in this study comprised both males and females, with and without disc displacement. A sufficiently large sample size with MRI-determined normal disc position could be used as pre-orthodontic controls,
- The effect of age on cephalometric measurements in the adolescent population was adequately controlled by making use of polynomial regression techniques,
- Multivariate statistical techniques were successfully employed to evaluate the combined contribution of various independent variables to the variability of the dependent variable

In addition to the strengths outlined above, limitations in the study have been identified and recommendations are suggested:

- This study was a cross-sectional evaluation of craniofacial morphology and TMJ disc status. Individuals presenting with disc displacement may have recently displaced the disc or may have been functioning with a compromised joint for some period of time. If disc displacement has an effect on the contribution of the condyle to facial development, then the effect should be larger for the patient who has been exposed to the effect for a longer period of time. This temporal association cannot be evaluated by making use of cross-sectional evaluations. A longitudinal investigation is required to investigate what effect the duration of displacement has on facial development.

- The objective of this study was to determine if disc displacement could be associated with specific facial patterns. Individuals seeking orthodontic consultation were included in the study but this sample was not representative of the general population. If the prevalence of the various degrees of internal derangement in the adolescent population is to be determined a random sample from the general population of adolescents will be required. It may also be argued that the population seeking orthodontic consultation was a biased sample since these individuals already had alterations in facial pattern and therefore the facial patterns identified had nothing to do with disc displacement. This may be true but will require a random sample from the general population for investigation.
- Lateral cephalometric radiographs were used to measure facial dimensions. These radiographs are two-dimensional representations of three-dimensional structures which impose certain limitations:
    1. Superimposition of bony structures makes identification of cephalometric landmarks difficult. Open mouth radiographs may however be used to aid in identification of mandibular structures.
    2. Bilateral structures are often superimposed and it becomes impossible to differentiate left from right. This is important when side specific effects need to be determined.
    3. Cephalometric measurements are often made from landmarks in the mid-sagittal plane to landmarks more laterally placed. The more laterally placed the landmark the greater the angle formed with the mid-sagittal plane and the more fore-shortened the projection onto the lateral cephalometric radiograph. This unseen dimension need to be considered when comparisons in facial dimensions are made.

4. Longitudinal evaluations assessing changes in facial morphology over time can only identify absolute changes that have taken place. Surface remodeling and rotations that occur as part of the adaptive capacity to compensate for growth alterations cannot be quantified directly by identifying structures on the external surfaces of bones. Osseous implants are necessary to fully appreciate the extent of growth rotations[20].

- A comprehensive medical and dental history was obtained from all individuals involved in the study but the effect of external factors on growth and development of the facial region could not be controlled. Digit habits, mouth-breathing, facial trauma, allergies and infections were tested in multiple regression analyses but proved to be inconsequential
- Although a standardized examination form was used to obtain clinical information the consistency of the observer in acquiring this data was never tested for reproducibility, reliability or drift in experience of the observer during the course of the investigation.

### 12.4 Future Investigations

The questions posed by the present study have resulted in an exponential growth in the number of questions for future investigations. Some of these research ideas arise as a result of the findings of the present study, while others stem from limitations encountered. It is hoped these suggestions will be food for thought for future investigations regarding adolescent craniofacial development:

As previously mentioned, a longitudinal evaluation of the changes in facial pattern that occur with time may shed light on the temporal association of disc displacement and craniofacial morphology. With the standardization of a study period for individuals with similar growth potential but with varying degrees of disc displacement, differences in the contribution of the condyle to facial dimensions may be noticed. Longitudinal investigation also has the potential of identifying which types of disc displacement may proceed to full disc displacement without reduction. Furthermore, a longitudinal evaluation may identify individuals who convert to craniofacial pain and dysfunction and may greatly enhance the diagnostic ability of the clinician.

In the near future, sagittal MR images of the joint will be able to be reconstructed to resemble the coronal images of the joint. Incorporation of coronal imaging information will allow for the three-dimensional revision of the joint. This reconstruction will contribute significantly to visualization of discal alterations and permit studies to be conducted on surface areas in contact with normal and displaced discs to understand more fully the stress distribution and lubrication properties of the disc involved in disc displacement.

Modern imaging technology is rapidly evolving and will soon be able to produce three-dimensional images of the craniofacial skeleton for evaluation. These advances will improve our appreciation of the magnitude of changes occurring as a consequence of growth and alteration in growth expression as a result of local and general environmental factors. Whether vector resolution, surface area measurements or volume determinations will prove to be most effective in describing facial morphology, awaits further investigation.

When considering the associations between disc displacement and adolescent craniofacial morphology, other factors influencing facial development need to be considered. The effect of muscle function needs to be quantified and the alterations in muscle function that may occur as a result of negative feedback from capsular receptors needs to be investigated. Electromyographic investigations may be used to determine if muscle tension is altered, recruitment patterns of muscle fibres become adapted and whether muscle fatique associated with muscle guarding occurs as a result of internal derangement. Volumetric determination of masticatory muscles can also be considered to assess whether muscle volume is associated with internal derangement and whether the load produced by muscles is similar in individuals with and without internal derangement.

It is hoped that in the near future the fluid content and distribution within the articular disc can be studied by MR imaging or spectroscopy. The present study hypothesizes that alteration in fluid distribution as a result of disc displacement leads to alterations in lubrication, load distribution, oxygenation, nutrition and hydration of the osseous articular cartilage. It is postulated that these changes result in damage to the proliferative cells within the cartilage which leads to reduced matrix and proteoglycan synthesis and a reduced contribution of condylar cartilage to mandibular development. Identification of alterations in fluid content within the disc may permit animal models to be established to examine the biochemical alterations within the articular tissues which accompany or precede fluid alterations and disc position changes, and which may shed light on the etiology of disc displacement.

## 12.5 Conclusions

A pilot study was conducted to test the association between disc displacement and craniofacial morphology in the adolescent population. The results of the pilot study were encouraging but deficiencies in classification of disc position on MR images requires the development of a new method for quantification of disc position. Subsequent studies showed that quantification of TMJ disc length and disc displacement is possible using standardized reference planes transferred from lateral cephalometric radiographs to MR images of the joint. Interobserver reliability studies showed that the quantification technique had moderate to substantial interobserver agreement when applied by four examiners with varied backgrounds and training in MRI interpretation. Furthermore, the quantification technique showed that as the magnitude of disc displacement increased the sagittal dimensions of the disc reduced.

The quantification technique was applied to MR images obtained from an adolescent sample to determine the disc status. This information was used in separate multivariate analyses for males and females to test the association between disc displacement and craniofacial morphology. In these analyses the effect of age on facial dimensions was controlled by making use of polynomial regression techniques. Regardless of gender, internal derangement of the TMJ was shown to be associated with the following facial features: a reduction in posterior facial height observed in both the posterior cranial base and ramus of the mandible, a reduction in sagittal dimensions of the mandible, an increase in the angle formed between the lower border of the mandible and mid-sagittal cranial base reference planes, and a moderate increase in anterior facial height. Alterations in vertical and sagittal maxillary position and dimensions were not consistently noted.

The facial pattern associated with internal derangement differs from that observed in individuals with chronic nasal obstruction in that the posterior facial height is reduced and the maxillary molar height is not increased in individuals with disc displacement. The facial pattern associated with internal derangement is however similar to that observed in individuals with juvenile rheumatoid arthritis but the alterations in individuals with disc displacement appear to be less severe. Identification of characteristic facial patterns associated with diagnosable disorders will greatly assist the clinician in diagnosis and treatment planning of individuals seeking treatment for malocclusions.

Evaluation of clinical signs and symptoms in the adolescent population identified that reproducible opening joint sounds were associated with disc displacement in both males and females. Symptoms of masseter muscle tenderness on palpation were also represented in both male and female regression analyses, but were not entered into the final female regression model. Further evaluation of signs and symptoms is necessary to determine whether this information can be used more appropriately to aid in the diagnosis of varying stages of internal derangement.

Finally, this study shows that internal derangement may be considered as a local environmental factor which influences joint function and can be associated with alterations in craniofacial morphology in the adolescent population. The clinician needs to be aware that internal derangement is another factor that must be considered when treatment planning adolescents with altered craniofacial morphology. Long term evaluation of these adolescents may shed light on the development of craniofacial disorders and pain in these individuals and may aid in providing palliative care at an earlier age.

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**University of Alberta**

# Adolescent Facial Morphology and TMJ Internal Derangement
## APPENDICES

by

Brian Nebbe

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in

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## Appendix 1

## TMJ Disc Fluid Content Determination: Magnetic Resonance Imaging

### Introduction

To date histological studies support claims of disc alteration and fibrosis of retrodiscal tissues associated with disc displacement[1-8]. These studies have been carried out on autopsy specimens or discs which have been removed as part of a discectomy procedure. Unfortunately the fluid content in these removed tissues cannot be preserved, so little can be said concerning the alteration in fluid content of the disc. Magnetic resonance imaging may be capable of determining altered fluid content in certain areas of the joint and more specifically the disc. A knowledge regarding the fluid content of the internally deranged disc may be of use to the researcher and clinician in determining the pathophysiology of joint disease. This may support the view that weeping lubrication provided by the normal disc is essential in maintaining the articular surfaces and providing nutrition to the structures of the joint.

### Objectives

- Develop a protocol whereby it may become possible to determine fluid content within various areas of the articular disc by making use of Nuclear Magnetic Resonance imaging.
- Determine if there is any difference in distribution of fluid, or fluid content in discs of subjects with normal disc position as compared to those with internal derangement.

### Study Outline and Materials

An MRI system utilizing a 3 Tesla magnet was used, with a custom designed surface receiver coil, to obtain images of the TMJ and the articular disc. An initial pilot study was carried out on consenting individuals for the purpose of determining the capabilities of the imaging technique. Axial scout images were produced to locate the condyle and determine the long axis of the condyle. Sagittal open and closed mouth images were obtained at right angles to the long axis of the condyle with 3 mm slice thickness and with 1 mm spacing between slices. Field-of-view of either 150 mm or 200 mm was digitized over an image matrix of 256 x 256 points.

### Results

A total of seven adult subjects were imaged (2 female, 5 male), 6 subjects were presumed to have normal disc position while one patient with TMD signs and symptoms was included in the pilot study. Three subjects were repeatedly imaged over a period of eight weeks. None of the images of the TMJs showed adequate resolution to differentiate the articular disc from other structures within the TMJ. It was not possible to determine the exact outline of the articular disc or the outline of the osseous articular structures. Various pulse sequences were attempted without improvement in image resolution.

### Discussion

Images produced utilizing the 3 Tesla magnet and with a unilateral surface coil did not produce images comparable to images produced with the previously used 1 Tesla magnet. The images generated by the 3 Tesla magnet lacked resolution and did not allow for adequate differentiation between tissues which constitute the TMJ. Therefore, it was not possible to estimate the fluid content within the articular disc since it was not possible to determine the exact location of the disc within the temporomandibular joint.

Poor resolution of the tissues of the TMJ could be attributed to susceptibility artifacts which occur when tissues of different density are adjacent to one another. In this instance the difference in densities for cortical bone of the mandibular condyle and for the posterior slope of the articular eminence relative to the proton density in the articular disc may have resulted in susceptibility artifacts. The cerebrospinal fluid which bathes the temporal lobe of the brain just superior to the TMJ as well as the air/tissue interface adjacent to the tMJ, may have been additional sources of susceptibility artifacts.

Magnetic susceptibility is a quantitative measure of a material's tendency to interact with and distort an applied magnetic field[9]. When an object with a susceptibility different from that of the surrounding tissue is placed within a homogeneous magnet, local magnetic field inhomogeneities are introduced[11]. These inhomogeneities produce image distortion. Susceptibility alters the positional accuracy of structures being imaged and produces image artifacts[9], thus the spatial geometry is, distorted. The amount of shift and distortion of objects depends on the form of the object and is proportional to the main field and inversely proportional to the gradient field strength[10]. Furthermore, the direction and shape of the deformation is correlated with gradient's orientation and polarity[10]. The magnetization of tissue within an applied magnetic field interferes with the frequency encoding process but does not affect the phase encoding[9].

Susceptibility also causes signal loss due to intra-voxel dephasing[11]. In some instances the distortions may be so strong that the signal from different volume elements are summed into the same image pixel. Comparison of images recorded with interchanged readout and preparation gradients or reversed readout gradient polarity may help to identify these artifacts[10].

A recent review of the literature[9] indicates that the susceptibility of cortical bone is slightly more diamagnetic than water and that obvious image distortion in the vicinity of large bones do not occur. Therefore, the susceptibility effect of cortical bone in the present study may be questioned and possibly the effect of brain tissue in the temporal lobe has a more dominant effect on image distortion and loss of image resolution.

## Conclusions

Our attempts to determine the fluid content within regions of the articular disc in individuals with normal and displaced discs was unsuccessful but greater attention to artifact reduction may improve future imaging attempts.

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## Appendix 2

## Pilot Study Raw Data

**Key:**

| | |
|---|---|
| AUFH | anterior upper face height (N-ANS') |
| ALFH | anterior lower face height (ANS'-Me) |
| TAFH | total anterior face height (N-Me) |
| RH | ramus height (Co-Go) |
| 6/PP | maxillary molar height perpendicular to palatal plane (OP-(ANS-PNS) |
| CL | corpus length (Go-Me) |

| No | Age | Sex | AUFH | ALFH | TAFH | RH | 6/PP | CL |
|---|---|---|---|---|---|---|---|---|
| 7793 | 11.93 | F | 57.1 | 64 | 119.9 | 50.3 | 21.4 | 69.3 |
| 7907 | 11 | F | 45.5 | 62.4 | 106.9 | 49.2 | 21.1 | 58.2 |
| 7971 | 12.77 | F | 50.5 | 61.9 | 112.3 | 54.3 | 20.4 | 72.5 |
| 8046 | 13.53 | F | 50.3 | 71.8 | 121.9 | 55.8 | 23.4 | 66.4 |
| 8063 | 12.32 | F | 51.3 | 59.9 | 110 | 50.6 | 18.2 | 69.5 |
| 8163 | 10.43 | F | 51.5 | 67 | 117.2 | 52.6 | 21 | 71 |
| 8244 | 15.73 | F | 52.3 | 63.6 | 115.6 | 51.7 | 21.4 | 64.4 |
| 8254 | 15.63 | F | 51.8 | 67.3 | 118.7 | 54.7 | 20 | 75.9 |
| 8255 | 10.76 | F | 53.2 | 65.3 | 116.8 | 53.5 | 17.6 | 70.8 |
| 8288 | 16.99 | F | 50.9 | 69 | 119.5 | 60.7 | 24.1 | 73.9 |
| 9062 | 16 | F | 62.3 | 88 | 150.2 | 55.9 | 26 | 84.2 |
| 9064 | 11.9 | F | 52 | 69 | 120.8 | 50.5 | 20.5 | 83.2 |
| 9087 | 14 | F | 50.9 | 67.7 | 118.2 | 52.5 | 20.1 | 71.3 |
| 9088 | 12.42 | F | 53.2 | 72.9 | 125 | 53.1 | 21.4 | 71.8 |
| 9124 | 12.12 | F | 49 | 58.3 | 106.3 | 47.9 | 18.6 | 67.9 |
| 9128 | 10.47 | F | 51.9 | 65.6 | 116.9 | 49.5 | 19.5 | 72.3 |
| 9162 | 15.26 | F | 53.7 | 60.7 | 114.4 | 55.1 | 21.9 | 72.6 |
| 9163 | 14.46 | F | 49.7 | 68.1 | 115.6 | 52.7 | 23.1 | 76.2 |
| 9164 | 11.78 | F | 50.8 | 66.9 | 117.7 | 50.5 | 22.8 | 71.9 |
| 9244 | 10.51 | F | 48 | 63.2 | 110.6 | 45 | 17.6 | 69.4 |
| 8261 | 14.64 | M | 49.9 | 67.5 | 116.8 | 57.3 | 22.2 | 74.2 |
| 8293 | 11.75 | M | 48 | 65.2 | 112.9 | 61.3 | 22 | 76.3 |
| 8294 | 10.84 | M | 46.1 | 58 | 103.7 | 52.5 | 18.2 | 68.9 |
| 9129 | 10.61 | M | 47.8 | 62.1 | 109.1 | 48.7 | 17.1 | 69.3 |
| 9161 | 15.63 | M | 47.5 | 69 | 116.3 | 55.1 | 21.4 | 70.3 |

## Appendix 2

## Pilot Study Raw Data (continued)

**Key:**

| | |
|---|---|
| Max | anteroposterior maxillary length (Co-ANS") |
| Mnd | anteroposterior mandibular length (Co-Me) |
| TPFH | total posterior face height (S-Go) |
| UPFH | upper posterior face height (ANS-PNS) perp SN |
| X | anteroposterior condyle position projected perpendicular to SN (x-S) |
| Y | vertical condylar position relative to SN (Co perp SN at x) |
| MP | mandibular plane angle (SN/Go-Me) |
| AGM | gonial angle (Ar-Go-Me) |

| No | Max | Mnd | TPFH | UPFH | "X"" " | "Y"" " | MP | AGM |
|---|---|---|---|---|---|---|---|---|
| 7793 | 90.4 | 110.2 | 73.7 | 46.2 | 18.7 | 16.9 | 39 | 129 |
| 7907 | 79.1 | 100 | 63.2 | 39.2 | 10 | 13.9 | 42 | 136 |
| 7971 | 85.7 | 112.7 | 73.9 | 47 | 12.8 | 19.4 | 31 | 126 |
| 8046 | 76.5 | 111.4 | 75.1 | 46.9 | 16.5 | 16.2 | 43 | 132.5 |
| 8063 | 90.9 | 107.2 | 70.9 | 47.9 | 17.2 | 17.5 | 32.5 | 127 |
| 8163 | 91.8 | 112 | 70.3 | 46 | 17 | 15.7 | 38 | 131 |
| 8244 | 78.2 | 106.3 | 68.3 | 45.1 | 14.5 | 12.8 | 43 | 135 |
| 8254 | 87.5 | 117.8 | 76.3 | 51.3 | 18.4 | 17.4 | 34 | 127 |
| 8255 | 92.6 | 112.1 | 71.7 | 46 | 15 | 17 | 37 | 131.5 |
| 8288 | 86.8 | 118.3 | 77.6 | 44.4 | 20.1 | 11.5 | 34 | 122 |
| 9062 | 93.1 | 131.8 | 79.1 | 53.9 | 20.2 | 20.9 | 51 | 140.1 |
| 9064 | 92 | 117.9 | 71.1 | 46.7 | 19.8 | 18 | 37 | 123 |
| 9087 | 82.3 | 112.3 | 71 | 49.5 | 18 | 14 | 40 | 131.1 |
| 9088 | 90.2 | 114.8 | 70.4 | 45.4 | 1804 | 14.3 | 45 | 135.5 |
| 9124 | 86.6 | 103.6 | 61.5 | 40.6 | 18.1 | 9.5 | 38.5 | 127 |
| 9128 | 85.9 | 110.2 | 72.9 | 46.4 | 22.8 | 17.9 | 37 | 126 |
| 9162 | 90.7 | 114.5 | 77.4 | 44 | 20.5 | 21.9 | 30 | 129 |
| 9163 | 97.9 | 115 | 73.3 | 43.4 | 24.9 | 16.6 | 34 | 124.9 |
| 9164 | 79.8 | 109.4 | 70.4 | 44.3 | 13.4 | 19.8 | 39 | 129 |
| 9244 | 83 | 102.7 | 61.6 | 39.6 | 14 | 10.5 | 45 | 125.3 |
| 8261 | 92 | 114.1 | 84.4 | 49 | 24.2 | 23.6 | 26 | 123 |
| 8293 | 91.3 | 119.6 | 81.5 | 45.5 | 18 | 19.2 | 25 | 126 |
| 8294 | 82.9 | 101.7 | 71.4 | 42 | 13.9 | 17.8 | 27 | 114 |
| 9129 | 87.4 | 103.8 | 67.3 | 42.9 | 18.3 | 16.2 | 34 | 124 |
| 9161 | 87.4 | 116 | 75.4 | 47.2 | 21.1 | 17.2 | 34 | 137.8 |

# Appendix 2

## Pilot Study Raw Data (continued)

**Key:**

| | |
|---|---|
| UI/LL | interincisal angle |
| SN/PP | palatal plane angle (SN/ANS-PNS) |
| PF:AF | posterior face height to anterior face height ratio (TPFH:ATFH) |
| UF:LF | anterior upper face height to lower anterior face height ratio (AUFH:ALFH) |
| LF:AF | anterior lower face height to anterior total face height ratio (ALFH:ATFH) |
| R TMJ | right temporomandibular joint angular disc displacement measure |
| L TMJ | left temporomandibular joint angular disc displacement measure |

| No | UI/II | SN/PP | PF:AF | UF:LF | LF:AF | R TMJ | L TMJ |
|---|---|---|---|---|---|---|---|
| 7793 | 131 | 14 | 0.615 | 0.892 | 0.534 | 47 | 95 |
| 7907 | 135 | 9 | 0.59 | 0.73 | 0.58 | 8 | 14 |
| 7971 | 132 | 6.5 | 0.66 | 0.82 | 0.55 | 6 | 10 |
| 8046 | 134 | 4 | 0.616 | 0.7 | 0.589 | 59 | 52 |
| 8063 | 132 | 5 | 0.645 | 0.856 | 0.545 | 77 | 61 |
| 8163 | 126 | 7 | 0.6 | 0.77 | 0.57 | 19 | 19 |
| 8244 | 150 | 11 | 0.591 | 0.822 | 0.55 | 49 | 75 |
| 8254 | 136 | 3 | 0.64 | 0.77 | 0.567 | 68 | 40 |
| 8255 | 132 | 10 | 0.614 | 0.81 | 0.56 | 35 | -8 |
| 8288 | 146 | 10 | 0.65 | 0.737 | 0.577 | 38 | 32 |
| 9062 | 134 | 7 | 0.527 | 0.708 | 0.586 | 10 | 4 |
| 9064 | 137.5 | 6 | 0.589 | 0.754 | 0.571 | 71 | 46 |
| 9087 | 146 | 3 | 0.601 | 0.752 | 0.573 | -4 | 0 |
| 9088 | 135 | 9.5 | 0.563 | 0.73 | 0.583 | -4 | -13 |
| 9124 | 121 | 11 | 0.58 | 0.84 | 0.548 | 6 | 4 |
| 9128 | 144 | 8.1 | 0.624 | 0.791 | 0.561 | 30 | 14 |
| 9162 | 139 | 13 | 0.677 | 0.885 | 0.531 | 53 | 0 |
| 9163 | 110 | 8.2 | 0.634 | 0.73 | 0.589 | 6.5 | 40 |
| 9164 | 132 | 9 | 0.598 | 0.759 | 0.568 | 55 | 15 |
| 9244 | 125.2 | 11 | 0.557 | 0.759 | 0.571 | 91 | 67 |
| 8261 | 115 | 1 | 0.723 | 0.74 | 0.578 | 7 | 0 |
| 8293 | 121 | 4 | 0.72 | 0.736 | 0.577 | -10 | -3 |
| 8294 | 143 | 5 | 0.689 | 0.795 | 0.56 | 0 | -8 |
| 9129 | 113 | 5.1 | 0.617 | 0.77 | 0.569 | 6 | 9 |
| 9161 | 143 | 2 | 0.648 | 0.688 | 0.593 | 0 | 6 |

## Appendix 3

## Age, Gender and Referral Source of Sample

| REF | SEX | Age | REF DR |
|---|---|---|---|
| 1782 | f | 14.307 | sequent |
| 2476 | m | 14.08 | sequent |
| 4005 | f | 13.915 | referred |
| 4038 | f | 11.50 | sequent |
| 4381 | f | 14.554 | referred |
| 4703 | f | 14.786 | sequent |
| 5105 | f | 14.573 | referred |
| 5748 | f | 12.772 | sequent |
| 6229 | f | 12.485 | sequent |
| 6429 | f | 13.699 | referred |
| 6796 | m | 13.389 | sequent |
| 7702 | f | 11.972 | referred |
| 7703 | f | 11.647 | referred |
| 7747 | f | 11.17 | sequent |
| 7749 | m | 10.99 | sequent |
| 7767 | m | 14.6 | sequent |
| 7793 | f | 11.997 | sequent |
| 7856 | m | 12.7 | sequent |
| 7907 | f | 10.11 | sequent |
| 7937 | m | 13.90 | sequent |
| 7939 | m | 10.819 | sequent |
| 7947 | f | 16.75 | sequent |
| 7963 | f | 10.84 | sequent |
| 7970 | m | 10.10 | sequent |
| 7971 | f | 12.77 | sequent |
| 8014 | m | 10.78 | sequent |
| 8046 | f | 13.515 | sequent |
| 8063 | f | 12.32 | sequent |
| 8066 | m | 10.80 | sequent |
| 8081 | m | 12.97 | sequent |
| 8089 | f | 10.57 | sequent |
| 8090 | f | 10.57 | sequent |
| 8121 | f | 10.73 | sequent |
| 8122 | f | 13.33 | sequent |
| 8163 | f | 10.43 | sequent |
| 8244 | f | 15.742 | sequent |

| REF | SEX | Age | REF.DR |
|---|---|---|---|
| 8254 | f | 15.619 | sequent |
| 8255 | f | 10.76 | sequent |
| 8258 | m | 9.84 | sequent |
| 8261 | m | 14.64 | sequent |
| 8288 | f | 16.99 | sequent |
| 8293 | m | 11.75 | sequent |
| 8294 | m | 10.84 | sequent |
| 9062 | f | 16.20 | referred |
| 9064 | f | 11.9 | sequent |
| 9087 | f | 14.30 | sequent |
| 9088 | f | 12.42 | referred |
| 9092 | f | 12.68 | referred |
| 9093 | f | 12.70 | sequent |
| 9124 | m | 12.12 | sequent |
| 9125 | f | 11.01 | sequent |
| 9128 | f | 10.47 | sequent |
| 9129 | m | 10.61 | sequent |
| 9161 | m | 15.63 | sequent |
| 9162 | f | 15.26 | sequent |
| 9163 | m | 14.48 | sequent |
| 9164 | f | 11.78 | sequent |
| 9202 | m | 17.09 | referred |
| 9244 | f | 10.51 | sequent |
| 9247 | m | 13.53 | sequent |
| 9273 | f | 15.13 | sequent |
| 9274 | f | 13.32 | referred |
| 9284 | m | 11.97 | sequent |
| 9309 | m | 14.02 | sequent |
| 9340 | f | 15.38 | sequent |
| 9344 | f | 14.7 | sequent |
| 9347 | m | 13.3 | sequent |
| 9382 | m | 14.86 | sequent |
| 9411 | m | 15.59 | sequent |
| 9467 | f | 11.95 | sequent |
| 9479 | f | 10.67 | sequent |
| 9559 | m | 10.35 | referred |
| 9606 | m | 7.27 | referred |
| 9650 | f | 12.40 | referred |
| 9700 | m | 13.22 | referred |
| 9702 | f | 10.01 | referred |
| 9713 | f | 12.89 | referred |

| REF | SEX | Age | REF DR |
|---|---|---|---|
| 9733 | m | 13.41 | sequent |
| 9872 | m | 15.26 | referred |
| 9873 | f | 12.21 | referred |
| 9903 | f | 16.11 | referred |
| 9910 | f | 15.97 | referred |
| 9919 | f | 20 | referred |
| 9938 | m | 15.25 | sequent |
| 9945 | m | 16.87 | referred |
| 9984 | f | 13.08 | referred |
| 9985 | f | 12.85 | sequent |
| 9988 | m | 10.69 | sequent |
| 10047 | m | 10.36 | referred |
| 10048 | f | 10.56 | sequent |
| 10050 | f | 16.01 | sequent |
| 10071 | m | 13.64 | sequent |
| 10110 | f | 14.78 | referred |
| 10112 | f | 13.94 | referred |
| 10133 | f | 11.17 | referred |
| 10140 | f | 15.47 | referred |
| 10141 | f | 12.39 | sequent |
| 10174 | m | 9.57 | referred |
| 10176 | f | 13.43 | referred |
| 10233 | f | 12.13 | referred |
| 10254 | f | 10.96 | sequent |
| 10282 | f | 13.64 | sequent |
| 10284 | m | 12.25 | sequent |
| 10315 | f | 11.74 | sequent |
| 10344 | f | 11.00 | referred |
| 10346 | f | 16 | sequent |
| 10354 | f | 12.87 | sequent |
| 10369 | m | 13.57 | referred |
| 10392 | f | 15.79 | referred |
| 10399 | f | 14.95 | sequent |
| 10423 | m | 14.18 | sequent |
| 10445 | m | 13.5 | sequent |
| 10447 | f | 11.35 | referred |
| 10485 | f | 13.57 | sequent |
| 10491 | f | 10.87 | sequent |
| 10495 | m | 12.16 | sequent |
| 10515 | f | 12.7 | sequent |
| 10517 | f | 13.25 | referred |

| REF | SEX | Age | REF DR |
|---|---|---|---|
| 10549 | f | 12.42 | referred |
| 10553 | m | 10.6 | sequent |
| 10554 | f | 14.18 | sequent |
| 10555 | f | 13.01 | sequent |
| 10569 | f | 10.72 | sequent |
| 10570 | m | 13.1 | sequent |
| 10571 | m | 13.15 | sequent |
| 10572 | f | 10.22 | sequent |
| 10573 | f | 14.87 | sequent |
| 10574 | m | 15.33 | sequent |
| 10575 | m | 12.52 | sequent |
| 10576 | m | 12.53 | sequent |
| 10586 | m | 13.85 | sequent |
| 10589 | f | 14.85 | referred |
| 10595 | f | 13.22 | sequent |
| 10596 | f | 13.23 | sequent |
| 10626 | m | 11.4 | sequent |
| 10627 | m | 13.41 | sequent |
| 10629 | f | 10.86 | sequent |
| 10631 | f | 13.71 | referred |
| 10638 | m | 13.19 | sequent |
| 10639 | m | 15.04 | sequent |
| 10640 | m | 12.9 | sequent |
| 10642 | m | 13.73 | sequent |
| 10643 | m | 14.95 | sequent |
| 10645 | f | 14.45 | referred |
| 10646 | f | 14.15 | sequent |
| 10647 | f | 12.36 | sequent |
| 10666 | m | 15.38 | sequent |
| 10667 | f | 12.69 | sequent |
| 10670 | m | 11.79 | sequent |
| 10671 | m | 16.86 | sequent |
| 10713 | f | 12.13 | referred |
| 10714 | f | 14.13 | sequent |
| 10716 | f | 12.73 | sequent |
| 10720 | f | 15.67 | referred |
| 10732 | f | 12.88 | sequent |
| 10733 | f | 11.8 | sequent |
| 10734 | m | 14.51 | sequent |
| 10736 | m | 10.63 | referred |
| 10737 | m | 15.78 | sequent |

| REF | SEX | Age | REF DR |
|---|---|---|---|
| 10740 | f | 15.15 | sequent |
| 10741 | f | 16.64 | referred |
| 10788 | f | 11.1 | sequent |
| 10791 | m | 15.07 | sequent |
| 10793 | f | 12.85 | referred |
| 10794 | f | 14.31 | sequent |
| 10833 | f | 16.1 | sequent |
| 10837 | m | 12.68 | sequent |
| 10839 | f | 15.43 | sequent |
| 10840 | f | 15.1 | sequent |
| 10877 | f | 10.05 | sequent |
| 10878 | m | 15.43 | sequent |
| 10879 | m | 13.37 | referred |
| 10882 | f | 11.93 | sequent |
| 10919 | f | 10.76 | referred |
| 10959 | f | 12.35 | sequent |
| 10960 | m | 11.41 | sequent |
| 10962 | m | 12.84 | sequent |
| 10969 | m | 10.8 | sequent |
| 10989 | f | 13.29 | referred |
| 10998 | f | 11.5 | sequent |
| 11004 | f | 11.46 | sequent |
| 11048 | f | 15.01 | referred |
| 11075 | f | 12.93 | referred |
| 11077 | f | 14.41 | referred |
| 11080 | m | 11.03 | sequent |
| 11108 | m | 11.02 | sequent |
| 11111 | m | 11.84 | sequent |
| 11146 | f | 12.76 | referred |
| 11440 | f | 9.05 | referred |
| no rads | m | 10.2 | referred |
| no rads | f | 15.6 | sequent |
| no rads | m | 13.4 | sequent |
| 11336 | m | 11.12 | referred |

## Appendix 4

## MRI Disc Length, Disc Displacement, Ratio, Subjective Grouping and Discriminant Classification per Sagittal TMJ Slice

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 1782 | L4 | 4.78 | 6.13 | 1.28 | 6 | 5 |
| 1782 | L5 | 6.69 | 4.19 | 0.63 | 6 | 4 |
| 1782 | L6 | 7.25 | 5.97 | 0.82 | 6 | 4 |
| 1782 | L7 | 5.76 | 5.5 | 0.96 | 6 | 4 |
| 1782 | L8 | 7.15 | 3.03 | 0.42 | 6 | 3 |
| 1782 | R2 | 4.73 | 4.82 | 1.02 | 6 | 4 |
| 1782 | R3 | 7.64 | 5.64 | 0.74 | 6 | 4 |
| 1782 | R4 | 5.71 | 6.62 | 1.16 | 6 | 5 |
| 1782 | R5 | 5.45 | 6.84 | 1.25 | 6 | 5 |
| 2476 | L3 | 10.07 | 2.29 | 0.23 | 6 | 3 |
| 2476 | L4 | 10.88 | 0.69 | 0.06 | 6 | 2 |
| 2476 | L5 | 11.28 | 0.12 | 0.01 | 6 | 1 |
| 2476 | L6 | 10.73 | 1.14 | 0.11 | 2 | 2 |
| 2476 | R1 | 7.97 | 0.25 | 0.03 | 6 | 1 |
| 2476 | R2 | 11.88 | 1.85 | 0.16 | 2 | 2 |
| 2476 | R3 | 10.83 | 0.81 | 0.08 | 2 | 2 |
| 2476 | R4 | 11.89 | 1.94 | 0.16 | 2 | 2 |
| 2476 | r5 | 11.93 | 1.89 | 0.16 | 3 | 2 |
| 4005 | L3 | 8.77 | 0.3 | 0.03 | 6 | 1 |
| 4005 | L4 | 9.63 | 0.97 | 0.1 | 6 | 2 |
| 4005 | L5 | 10.5 | 0.11 | 0.01 | 6 | 1 |
| 4005 | L6 | 9.6 | -0.66 | -0.07 | 6 | 1 |
| 4005 | R2 | 10.31 | -0.15 | -0.01 | 1 | 1 |
| 4005 | R3 | 12.19 | -0.44 | -0.04 | 1 | 1 |
| 4005 | R4 | 11.38 | -1.06 | -0.09 | 1 | 1 |
| 4005 | R5 | 9.94 | -1.22 | -0.12 | 1 | 1 |
| 4381 | L3 | 2.28 | 5.25 | 2.3 | 5 | 5 |
| 4381 | L4 | 2.71 | 2.2 | 0.81 | 5 | 4 |
| 4381 | L5 | 2.05 | 5.37 | 2.63 | 5 | 5 |
| 4381 | L6 | 1.55 | 7.15 | 4.6 | 5 | 5 |
| 4381 | R2 | 9.93 | 7.91 | 0.8 | 5 | 4 |
| 4381 | R3 | 9.91 | 7.88 | 0.8 | 6 | 4 |
| 4381 | R4 | 3.05 | 8.08 | 2.65 | 5 | 5 |
| 4381 | R5 | 3.1 | 8.13 | 2.62 | 6 | 5 |
| 4381 | R6 | 1.96 | 5.97 | 3.04 | 5 | 5 |
| 4381 | R7 | 1.95 | 6 | 3.07 | 6 | 5 |
| 4381 | R8 | 2.07 | 4.64 | 2.24 | 5 | 5 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 4381 | R9 | 2.11 | 4.68 | 2.22 | 6 | 5 |
| 4703 | R5 | 5.22 | 7.18 | 1.38 | 5 | 5 |
| 4703 | R6 | 3.63 | 5.57 | 1.53 | 5 | 5 |
| 5105 | L2 | 5.44 | 4.79 | 0.88 | 6 | 4 |
| 5105 | L3 | 6.85 | 6.22 | 0.91 | 4 | 4 |
| 5105 | L4 | 6.94 | 6.33 | 0.91 | 6 | 4 |
| 5105 | L5 | 4.53 | 4.94 | 1.09 | 4 | 5 |
| 5105 | L6 | 4.52 | 5.07 | 1.12 | 6 | 5 |
| 5105 | L7 | 5.48 | 5.26 | 0.96 | 4 | 4 |
| 5105 | L8 | 5.46 | 5.27 | 0.96 | 6 | 4 |
| 5105 | R1 | 9.68 | 8.25 | 0.85 | 4 | 4 |
| 5105 | R2 | 9.67 | 8.32 | 0.86 | 6 | 4 |
| 5105 | R3 | 5.87 | 6.35 | 1.08 | 4 | 5 |
| 5105 | R4 | 5.92 | 6.45 | 1.09 | 6 | 5 |
| 5105 | R5 | 6.33 | 6.37 | 1.01 | 4 | 4 |
| 5105 | R6 | 6.37 | 6.39 | 1 | 6 | 4 |
| 5748 | L2 | 8.37 | -1.2 | -0.14 | 6 | 1 |
| 5748 | L3 | 10.69 | 1.74 | 0.16 | 6 | 2 |
| 5748 | L4 | 11.01 | 3.05 | 0.28 | 3 | 3 |
| 5748 | L5 | 10.97 | 7.89 | 0.72 | 6 | 4 |
| 5748 | L6 | 13.17 | 3.62 | 0.27 | 3 | 3 |
| 5748 | L7 | 13.06 | 9.52 | 0.73 | 6 | 4 |
| 5748 | R2 | 4.79 | 5.97 | 1.25 | 6 | 5 |
| 5748 | R3 | 7.99 | 7.23 | 0.9 | 6 | 4 |
| 5748 | R4 | 5.62 | 5.83 | 1.04 | 6 | 4 |
| 5748 | R5 | 4.31 | 3.97 | 0.92 | 6 | 4 |
| 6229 | L3 | 11.41 | 0.79 | 0.07 | 1 | 2 |
| 6229 | L4 | 11.53 | 0.81 | 0.07 | 2 | 2 |
| 6229 | L5 | 10.16 | -0.12 | -0.01 | 1 | 1 |
| 6229 | L6 | 10.86 | 0.16 | 0.01 | 1 | 1 |
| 6229 | L7 | 9.15 | 0.34 | 0.04 | 1 | 1 |
| 6229 | r3 | 7.21 | 5.25 | 0.73 | 3 | 4 |
| 6229 | R4 | 10.92 | 1.36 | 0.12 | 2 | 2 |
| 6229 | R5 | 12.54 | 1.18 | 0.09 | 2 | 2 |
| 6229 | R6 | 11.98 | 0.34 | 0.03 | 2 | 1 |
| 6429 | L2 | 5.42 | 5.64 | 1.04 | 5 | 4 |
| 6429 | L3 | 6.1 | 4.93 | 0.81 | 5 | 4 |
| 6429 | L4 | 6.83 | 5.95 | 0.87 | 5 | 4 |
| 6429 | L5 | 7.05 | 6.06 | 0.86 | 5 | 4 |
| 6429 | R4 | 11.12 | 5.56 | 0.5 | 4 | 4 |
| 6429 | R5 | 10.12 | 6.07 | 0.6 | 4 | 4 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 6429 | R6 | 13.1 | 0.16 | 0.01 | 6 | 1 |
| 6429 | R7 | 12.07 | 2.35 | 0.19 | 3 | 2 |
| 6796 | L3 | 11.57 | -0.79 | -0.07 | 1 | 1 |
| 6796 | L4 | 11.65 | -0.22 | -0.02 | 1 | 1 |
| 6796 | L5 | 10.25 | -0.19 | -0.02 | 1 | 1 |
| 6796 | L6 | 10.49 | 0.3 | 0.03 | 1 | 1 |
| 6796 | R3 | 10.7 | -0.29 | -0.03 | 1 | 1 |
| 6796 | R4 | 12.28 | 0.84 | 0.07 | 1 | 2 |
| 6796 | R5 | 9.67 | -0.38 | -0.04 | 1 | 1 |
| 6796 | R6 | 9.19 | -0.09 | -0.01 | 1 | 1 |
| 7702 | L2 | 5.27 | 9.22 | 1.75 | 5 | 5 |
| 7702 | L3 | 5.34 | 8.99 | 1.68 | 5 | 5 |
| 7702 | L4 | 5.49 | 9.19 | 1.67 | 6 | 5 |
| 7702 | L5 | 5.34 | 8.99 | 1.68 | 5 | 5 |
| 7702 | L6 | 5.49 | 9.05 | 1.65 | 6 | 5 |
| 7702 | L7 | 5.06 | 8.87 | 1.75 | 5 | 5 |
| 7702 | L8 | 5.01 | 8.95 | 1.79 | 6 | 5 |
| 7702 | R2 | 6.6 | 5.82 | 0.88 | 5 | 4 |
| 7702 | R3 | 6.63 | 5.91 | 0.89 | 6 | 4 |
| 7702 | R4 | 6.31 | 6.2 | 0.98 | 5 | 4 |
| 7702 | R5 | 6.39 | 6.22 | 0.97 | 6 | 4 |
| 7702 | R6 | 5.79 | 6.65 | 1.15 | 5 | 5 |
| 7702 | R7 | 5.84 | 6.66 | 1.14 | 6 | 5 |
| 7702 | R8 | 5.19 | 7.17 | 1.38 | 5 | 5 |
| 7702 | R9 | 5.36 | 7.23 | 1.35 | 6 | 5 |
| 7703 | L3 | 2 | 7.09 | 3.55 | 6 | 5 |
| 7703 | L4 | 4.06 | 4.68 | 1.15 | 6 | 5 |
| 7703 | L5 | 2.92 | 4.76 | 1.63 | 6 | 5 |
| 7703 | R4 | 3.43 | 4.98 | 1.45 | 5 | 5 |
| 7703 | R5 | 3.07 | 4.19 | 1.37 | 5 | 5 |
| 7703 | R6 | 2.46 | 4.15 | 1.69 | 5 | 5 |
| 7703 | R7 | 4.26 | 3.06 | 0.72 | 5 | 4 |
| 7747 | L3 | 12.06 | 2.08 | 0.17 | 6 | 2 |
| 7747 | L4 | 11.55 | 1.54 | 0.13 | 6 | 2 |
| 7747 | L5 | 12.48 | 1.25 | 0.1 | 6 | 2 |
| 7747 | L6 | 11.34 | 1.4 | 0.12 | 6 | 2 |
| 7747 | R2 | 10.33 | 1.12 | 0.11 | 6 | 2 |
| 7747 | R3 | 12.2 | 4.72 | 0.39 | 6 | 3 |
| 7747 | R4 | 12.2 | 3.35 | 0.27 | 6 | 3 |
| 7749 | L3 | 10.5 | 0.8 | 0.08 | 6 | 2 |
| 7749 | L4 | 10.17 | 1.43 | 0.14 | 6 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 7749 | L5 | 10.19 | 1.74 | 0.17 | 6 | 2 |
| 7749 | L6 | 9.34 | 1.14 | 0.12 | 6 | 2 |
| 7749 | R4 | 7.77 | 0.94 | 0.12 | 2 | 2 |
| 7749 | R5 | 11.52 | 0.93 | 0.08 | 2 | 2 |
| 7749 | R6 | 10.31 | 1.25 | 0.12 | 2 | 2 |
| 7767 | L1 | 9.98 | 0.12 | 0.01 | 1 | 1 |
| 7767 | L2 | 10.06 | 0.11 | 0.01 | 6 | 1 |
| 7767 | L3 | 11.37 | 0.08 | 0.01 | 1 | 1 |
| 7767 | L4 | 11.41 | 0.12 | 0.01 | 6 | 1 |
| 7767 | L5 | 11.59 | 0.55 | 0.05 | 1 | 2 |
| 7767 | L6 | 11.67 | 0.63 | 0.05 | 6 | 2 |
| 7767 | L7 | 9.74 | 0.11 | 0.01 | 1 | 1 |
| 7767 | L8 | 9.79 | -0.02 | 0 | 6 | 1 |
| 7767 | R2 | 9.81 | 3.63 | 0.37 | 6 | 3 |
| 7767 | R3 | 10.03 | -0.16 | -0.02 | 1 | 1 |
| 7767 | R4 | 10 | -0.18 | -0.02 | 6 | 1 |
| 7767 | R5 | 9.51 | -0.87 | -0.09 | 1 | 1 |
| 7767 | R6 | 9.65 | -0.9 | -0.09 | 6 | 1 |
| 7767 | R7 | 11.56 | -0.24 | -0.02 | 1 | 1 |
| 7767 | R8 | 11.57 | -0.26 | -0.02 | 6 | 1 |
| 7793 | L2 | 6.98 | 4.46 | 0.64 | 6 | 4 |
| 7793 | L3 | 4.63 | 9.54 | 2.06 | 6 | 5 |
| 7793 | L4 | 5.24 | 9.37 | 1.79 | 6 | 5 |
| 7793 | L5 | 5.03 | 6.76 | 1.34 | 6 | 5 |
| 7793 | L6 | 3.97 | 5.32 | 1.34 | 6 | 5 |
| 7793 | R3 | 6.45 | 3.92 | 0.61 | 6 | 4 |
| 7793 | R4 | 7.23 | 3.62 | 0.5 | 6 | 4 |
| 7793 | R5 | 8.68 | 2.63 | 0.3 | 6 | 3 |
| 7793 | R6 | 8.84 | 2.31 | 0.26 | 6 | 3 |
| 7856 | L2 | 8.41 | 3.13 | 0.37 | 6 | 3 |
| 7856 | L3 | 8.91 | 2.18 | 0.25 | 6 | 3 |
| 7856 | L4 | 9.32 | 5.25 | 0.56 | 6 | 4 |
| 7856 | L5 | 6.27 | 4.17 | 0.66 | 6 | 4 |
| 7856 | R1 | 12.67 | 0.21 | 0.02 | 6 | 1 |
| 7856 | R2 | 12.26 | 0.39 | 0.03 | 6 | 1 |
| 7856 | R3 | 11.52 | 0.51 | 0.04 | 6 | 1 |
| 7856 | R4 | 9.69 | 1.49 | 0.15 | 6 | 2 |
| 7939 | L2 | 8.64 | -0.71 | -0.08 | 6 | 1 |
| 7939 | L3 | 8.8 | -0.36 | -0.04 | 6 | 1 |
| 7939 | L4 | 10.72 | -1.67 | -0.16 | 6 | 1 |
| 7939 | L5 | 11.03 | -0.24 | -0.02 | 6 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 7939 | R2 | 11.4 | 0.15 | 0.01 | 6 | 1 |
| 7939 | R3 | 9.86 | -0.33 | -0.03 | 6 | 1 |
| 7939 | R4 | 7.7 | 1.26 | 0.16 | 6 | 2 |
| 7939 | R5 | 6.45 | 3.57 | 0.55 | 6 | 4 |
| 7947 | L1 | 9.69 | 4.61 | 0.48 | 6 | 3 |
| 7947 | L2 | 12.47 | 4.96 | 0.4 | 3 | 3 |
| 7947 | L3 | 13.73 | 3.7 | 0.27 | 3 | 3 |
| 7947 | L4 | 14.75 | 1.85 | 0.13 | 3 | 2 |
| 7947 | L5 | 13.56 | 2.36 | 0.17 | 3 | 2 |
| 7947 | R3 | 9.49 | 1.22 | 0.13 | 2 | 2 |
| 7947 | R4 | 13.18 | 1.52 | 0.12 | 2 | 2 |
| 7947 | R5 | 14.83 | 0.52 | 0.04 | 6 | 1 |
| 7947 | R6 | 15.57 | 3.42 | 0.22 | 6 | 2 |
| 7963 | L2 | 9.56 | 1.3 | 0.14 | 6 | 2 |
| 7963 | L3 | 11.34 | 2.85 | 0.25 | 3 | 3 |
| 7963 | L4 | 11.33 | 2.91 | 0.26 | 6 | 3 |
| 7963 | L5 | 10.52 | 3.28 | 0.31 | 3 | 3 |
| 7963 | L6 | 10.55 | 3.28 | 0.31 | 6 | 3 |
| 7963 | L7 | 9.27 | 3.62 | 0.39 | 3 | 3 |
| 7963 | L8 | 9.23 | 3.59 | 0.39 | 6 | 3 |
| 7971 | L1 | 8.71 | 1.27 | 0.15 | 6 | 2 |
| 7971 | L2 | 9.17 | 0.55 | 0.06 | 6 | 2 |
| 7971 | L3 | 9.95 | 0.96 | 0.1 | 6 | 2 |
| 7971 | L4 | 10.45 | -1.24 | -0.12 | 6 | 1 |
| 7971 | R1 | 11.54 | 0.25 | 0.02 | 6 | 1 |
| 7971 | R2 | 11.31 | -0.16 | -0.01 | 6 | 1 |
| 7971 | R3 | 10.81 | 0.73 | 0.07 | 6 | 2 |
| 7971 | R4 | 10.03 | 1.13 | 0.11 | 6 | 2 |
| 8014 | L3 | 5.13 | 5.61 | 1.09 | 6 | 5 |
| 8014 | L4 | 6.98 | 5.55 | 0.79 | 6 | 4 |
| 8014 | L5 | 5.78 | 4.96 | 0.86 | 6 | 4 |
| 8014 | R1 | 10.13 | 1.31 | 0.13 | 6 | 2 |
| 8014 | R2 | 11.02 | -0.37 | -0.03 | 6 | 1 |
| 8014 | R3 | 10.57 | -0.98 | -0.09 | 6 | 1 |
| 8014 | R4 | 11.3 | -0.61 | -0.05 | 6 | 1 |
| 8046 | L4 | 5.35 | 3.28 | 0.61 | 6 | 4 |
| 8046 | L5 | 8.43 | 5.5 | 0.65 | 6 | 4 |
| 8046 | L6 | 12.01 | 3.17 | 0.26 | 6 | 3 |
| 8046 | L7 | 6.7 | -0.28 | -0.04 | 6 | 1 |
| 8046 | R1 | 7.24 | 4.89 | 0.67 | 6 | 4 |
| 8046 | R2 | 6.7 | 3.35 | 0.5 | 6 | 4 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 8046 | R3 | 5.7 | 3.99 | 0.7 | 6 | 4 |
| 8046 | R4 | 4.95 | 5.75 | 1.16 | 6 | 5 |
| 8063 | L2 | 9.96 | 2.78 | 0.28 | 6 | 3 |
| 8063 | L3 | 8.09 | 2.79 | 0.34 | 6 | 3 |
| 8063 | L4 | 8.67 | 2.26 | 0.26 | 6 | 3 |
| 8063 | L5 | 6.92 | 0.74 | 0.11 | 6 | 2 |
| 8063 | R2 | 8.52 | 2.96 | 0.35 | 6 | 3 |
| 8063 | R3 | 8.65 | 4.69 | 0.54 | 6 | 4 |
| 8063 | R4 | 8.77 | 3.39 | 0.39 | 6 | 3 |
| 8063 | R5 | 10.77 | 3.29 | 0.31 | 6 | 3 |
| 8081 | L1 | 7.46 | 2.66 | 0.36 | 6 | 3 |
| 8081 | L2 | 7.05 | 1.97 | 0.28 | 6 | 3 |
| 8081 | L3 | 10.25 | -0.01 | 0 | 6 | 1 |
| 8081 | L4 | 6.94 | 2.2 | 0.32 | 6 | 3 |
| 8081 | R3 | 8.22 | 0.51 | 0.06 | 6 | 2 |
| 8081 | R4 | 8.96 | 1.15 | 0.13 | 6 | 2 |
| 8081 | R5 | 11.37 | 2.02 | 0.18 | 6 | 2 |
| 8089 | L1 | 11.9 | 0.32 | 0.03 | 6 | 1 |
| 8089 | L2 | 13 | 1.96 | 0.15 | 6 | 2 |
| 8089 | L3 | 7.61 | -1.92 | -0.25 | 6 | 1 |
| 8089 | L4 | 9.2 | 0.87 | 0.09 | 6 | 2 |
| 8089 | R3 | 6.16 | 1.4 | 0.23 | 6 | 3 |
| 8089 | R4 | 7.67 | 4.65 | 0.61 | 6 | 4 |
| 8089 | R5 | 8.4 | 1.38 | 0.16 | 6 | 2 |
| 8089 | R6 | 7.68 | 5.27 | 0.69 | 6 | 4 |
| 8090 | L2 | 8.03 | 5.34 | 0.67 | 6 | 4 |
| 8090 | L3 | 13 | 0.64 | 0.05 | 6 | 2 |
| 8090 | L4 | 15.24 | 1.05 | 0.07 | 6 | 2 |
| 8090 | L5 | 4.13 | -0.06 | -0.01 | 6 | 1 |
| 8090 | R3 | 12.67 | 0.15 | 0.01 | 6 | 1 |
| 8090 | R4 | 13.71 | 0.58 | 0.04 | 6 | 2 |
| 8090 | R5 | 13.08 | 0.04 | 0 | 6 | 1 |
| 8090 | R6 | 11.25 | 1.83 | 0.16 | 6 | 2 |
| 8121 | L1 | 9.19 | 5.13 | 0.56 | 4 | 4 |
| 8121 | L2 | 10.14 | 3.3 | 0.33 | 3 | 3 |
| 8121 | L3 | 11.15 | 3.88 | 0.35 | 3 | 3 |
| 8121 | L4 | 10.5 | 3.41 | 0.32 | 3 | 3 |
| 8121 | L5 | 8.82 | 1.36 | 0.15 | 6 | 2 |
| 8121 | R2 | 7.54 | 2.72 | 0.36 | 6 | 3 |
| 8121 | R3 | 10.4 | 2.99 | 0.29 | 6 | 3 |
| 8121 | R4 | 9.95 | 3.73 | 0.38 | 3 | 3 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 8121 | R5 | 10.27 | 3.23 | 0.31 | 6 | 3 |
| 8121 | R6 | 10.78 | 3.1 | 0.29 | 3 | 3 |
| 8121 | R7 | 11.24 | 3.02 | 0.27 | 6 | 3 |
| 8121 | R8 | 11.66 | 1.63 | 0.14 | 2 | 2 |
| 8122 | L1 | 12.78 | 4.33 | 0.34 | 6 | 3 |
| 8122 | L2 | 13.86 | 2.27 | 0.16 | 2 | 2 |
| 8122 | L3 | 13.75 | 0.66 | 0.05 | 2 | 2 |
| 8122 | L4 | 13.22 | 0.77 | 0.06 | 2 | 2 |
| 8122 | L5 | 11.95 | 2.21 | 0.19 | 2 | 2 |
| 8122 | L6 | 11.96 | 2.22 | 0.19 | 3 | 2 |
| 8122 | R3 | 9.07 | -0.38 | -0.04 | 6 | 1 |
| 8122 | R4 | 12.36 | 0.93 | 0.07 | 6 | 2 |
| 8122 | R5 | 13.2 | 1.27 | 0.1 | 6 | 2 |
| 8122 | R6 | 12.19 | 3.9 | 0.32 | 6 | 3 |
| 8163 | L2 | 8.51 | 2.13 | 0.25 | 3 | 3 |
| 8163 | L3 | 11.33 | 0.96 | 0.08 | 6 | 2 |
| 8163 | L4 | 12.49 | 1.43 | 0.11 | 6 | 2 |
| 8163 | R2 | 13.53 | 1.55 | 0.11 | 6 | 2 |
| 8163 | R3 | 11.05 | -0.28 | -0.03 | 6 | 1 |
| 8163 | R4 | 11.47 | -0.54 | -0.05 | 6 | 1 |
| 8163 | R5 | 8.57 | 2.45 | 0.29 | 6 | 3 |
| 8244 | L3 | 6.76 | 7.36 | 1.09 | 6 | 5 |
| 8244 | L4 | 6.35 | 10.15 | 1.6 | 6 | 5 |
| 8244 | L5 | 7.59 | 9.15 | 1.21 | 6 | 5 |
| 8244 | L6 | 7.77 | 5.4 | 0.69 | 6 | 4 |
| 8244 | R1 | 5.63 | 4.59 | 0.82 | 4 | 4 |
| 8244 | R2 | 8.46 | 5.28 | 0.62 | 4 | 4 |
| 8244 | R3 | 9.42 | 5.97 | 0.63 | 4 | 4 |
| 8244 | R4 | 5.75 | 4.88 | 0.85 | 4 | 4 |
| 8254 | L3 | 9.08 | 2.99 | 0.33 | 4 | 3 |
| 8254 | L4 | 10.01 | 5.01 | 0.5 | 4 | 4 |
| 8254 | L5 | 13.89 | 2.91 | 0.21 | 6 | 2 |
| 8254 | L6 | 8.13 | 4.52 | 0.56 | 4 | 4 |
| 8254 | L7 | 7.8 | 3.18 | 0.41 | 4 | 3 |
| 8254 | R2 | 6.26 | 7.61 | 1.22 | 5 | 5 |
| 8254 | R3 | 4.77 | 7.95 | 1.67 | 5 | 5 |
| 8254 | R4 | 6.17 | 10.77 | 1.74 | 5 | 5 |
| 8254 | R5 | 3.3 | 6.85 | 2.08 | 5 | 5 |
| 8255 | L3 | 13.59 | 0.58 | 0.04 | 6 | 2 |
| 8255 | L4 | 12.42 | 0.2 | 0.02 | 6 | 1 |
| 8255 | L5 | 10.5 | -0.64 | -0.06 | 6 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 8255 | L6 | 10.29 | -0.33 | -0.03 | 6 | 1 |
| 8255 | R2 | 9.69 | 1.39 | 0.14 | 6 | 2 |
| 8255 | R3 | 10.31 | 1.55 | 0.15 | 6 | 2 |
| 8255 | R4 | 12.83 | 3.66 | 0.28 | 3 | 3 |
| 8255 | R5 | 12.67 | 3.57 | 0.28 | 6 | 3 |
| 8255 | R6 | 12.21 | 2.81 | 0.23 | 3 | 2 |
| 8258 | L3 | 9.93 | 0.41 | 0.04 | 6 | 1 |
| 8258 | L4 | 12.16 | 0.01 | 0 | 6 | 1 |
| 8258 | L5 | 10.11 | -0.8 | -0.08 | 6 | 1 |
| 8258 | L6 | 10.52 | 1.66 | 0.16 | 2 | 2 |
| 8258 | L7 | 10.61 | 1.74 | 0.16 | 6 | 2 |
| 8258 | R1 | 10.77 | 1.6 | 0.15 | 6 | 2 |
| 8258 | R2 | 9.28 | -0.12 | -0.01 | 6 | 1 |
| 8258 | R3 | 12.02 | -0.89 | -0.07 | 6 | 1 |
| 8258 | R4 | 11.57 | 0.92 | 0.08 | 6 | 2 |
| 8261 | L3 | 10.88 | -0.67 | -0.06 | 6 | 1 |
| 8261 | L4 | 12.86 | 0.28 | 0.02 | 6 | 1 |
| 8261 | L5 | 12.86 | 1.02 | 0.08 | 6 | 2 |
| 8261 | L6 | 11.18 | -0.18 | -0.02 | 6 | 1 |
| 8261 | R3 | 12.08 | 0.24 | 0.02 | 6 | 1 |
| 8261 | R4 | 13.2 | 0.35 | 0.03 | 6 | 1 |
| 8261 | R5 | 12.44 | 1.37 | 0.11 | 6 | 2 |
| 8288 | L3 | 12.01 | 3.42 | 0.28 | 3 | 3 |
| 8288 | L3 | 12.02 | 3.39 | 0.28 | 6 | 3 |
| 8288 | L4 | 10.46 | 3.99 | 0.38 | 3 | 3 |
| 8288 | L4 | 10.4 | 4.07 | 0.39 | 4 | 3 |
| 8288 | L4 | 10.45 | 3.99 | 0.38 | 6 | 3 |
| 8288 | L5 | 6.83 | 3.42 | 0.5 | 3 | 4 |
| 8288 | L5 | 6.82 | 3.41 | 0.5 | 4 | 4 |
| 8288 | L5 | 6.96 | 3.48 | 0.5 | 6 | 4 |
| 8288 | L6 | 5.89 | 2.94 | 0.5 | 3 | 4 |
| 8288 | L6 | 5.86 | 2.93 | 0.5 | 4 | 4 |
| 8288 | L6 | 5.89 | 2.94 | 0.5 | 6 | 4 |
| 8288 | R1 | 9.21 | 0.44 | 0.05 | 6 | 1 |
| 8288 | R2 | 10.28 | 1.37 | 0.13 | 6 | 2 |
| 8288 | R3 | 12.53 | 2.15 | 0.17 | 6 | 2 |
| 8288 | R4 | 9.86 | 4.31 | 0.44 | 4 | 3 |
| 8293 | L3 | 9.21 | -0.6 | -0.07 | 6 | 1 |
| 8293 | L4 | 10.67 | 0.26 | 0.02 | 6 | 1 |
| 8293 | L5 | 10.99 | 0.31 | 0.03 | 6 | 1 |
| 8293 | L6 | 10.68 | 1.55 | 0.14 | 6 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 8293 | L7 | 11.79 | 0.78 | 0.07 | 6 | 2 |
| 8293 | R1 | 10 | 0.14 | 0.01 | 6 | 1 |
| 8293 | R2 | 11.42 | 0.4 | 0.04 | 6 | 1 |
| 8293 | R3 | 11.74 | -0.53 | -0.04 | 6 | 1 |
| 8293 | R4 | 10.55 | -0.37 | -0.04 | 6 | 1 |
| 8294 | L3 | 8.6 | -1.04 | -0.12 | 6 | 1 |
| 8294 | L4 | 8.6 | -0.98 | -0.11 | 6 | 1 |
| 8294 | L5 | 9.67 | -2.03 | -0.21 | 6 | 1 |
| 8294 | L6 | 9.05 | -1.62 | -0.18 | 6 | 1 |
| 8294 | R1 | 9.76 | 0.78 | 0.08 | 6 | 2 |
| 8294 | R2 | 10.26 | 1.15 | 0.11 | 6 | 2 |
| 8294 | R3 | 11.82 | 0.89 | 0.08 | 6 | 2 |
| 8294 | R4 | 8.67 | 2.91 | 0.34 | 6 | 3 |
| 9064 | L3 | 3.31 | 3.51 | 1.06 | 5 | 4 |
| 9064 | L4 | 7.52 | 7.76 | 1.03 | 5 | 5 |
| 9064 | L5 | 4.29 | 9.9 | 2.31 | 5 | 5 |
| 9064 | L6 | 5.7 | 9.14 | 1.6 | 5 | 5 |
| 9064 | R2 | 8.42 | 6.11 | 0.73 | 5 | 4 |
| 9064 | R3 | 5.21 | 7.58 | 1.45 | 5 | 5 |
| 9064 | R4 | 5.38 | 7.34 | 1.36 | 5 | 5 |
| 9064 | R5 | 4.88 | 5.86 | 1.2 | 5 | 5 |
| 9088 | L4 | 12.42 | 0.64 | 0.05 | 1 | 2 |
| 9088 | L5 | 10.88 | 0.26 | 0.02 | 1 | 1 |
| 9088 | L6 | 10.58 | 0.89 | 0.08 | 1 | 2 |
| 9088 | L7 | 9.7 | 0.38 | 0.04 | 1 | 1 |
| 9092 | L3 | 8.12 | 1.47 | 0.18 | 1 | 2 |
| 9092 | L4 | 8.76 | 0.57 | 0.07 | 1 | 2 |
| 9092 | L5 | 9.49 | 1.1 | 0.12 | 1 | 2 |
| 9092 | L6 | 10.4 | 0.47 | 0.04 | 1 | 1 |
| 9092 | R3 | 3.18 | 8.97 | 2.82 | 6 | 5 |
| 9092 | R4 | 5.18 | 9.98 | 1.93 | 6 | 5 |
| 9092 | R5 | 4.09 | 10.12 | 2.47 | 6 | 5 |
| 9092 | R6 | 4.81 | 10.21 | 2.12 | 6 | 5 |
| 9124 | L3 | 4.98 | 0.05 | 0.01 | 6 | 1 |
| 9124 | L4 | 5.98 | 0.75 | 0.13 | 2 | 2 |
| 9124 | L5 | 8.24 | 1.4 | 0.17 | 2 | 2 |
| 9124 | L6 | 8.5 | 0.48 | 0.06 | 2 | 2 |
| 9125 | L3 | 9.51 | 1.63 | 0.17 | 1 | 2 |
| 9125 | L4 | 9.65 | 1.56 | 0.16 | 3 | 2 |
| 9125 | L5 | 8.71 | 0.86 | 0.1 | 1 | 2 |
| 9125 | L6 | 8.59 | 0.45 | 0.05 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 9125 | L7 | 8.75 | 0.67 | 0.08 | 1 | 2 |
| 9125 | R1 | 9.05 | 1.31 | 0.15 | 1 | 2 |
| 9125 | R2 | 8.95 | 1.31 | 0.15 | 6 | 2 |
| 9125 | R3 | 10.05 | 0.11 | 0.01 | 1 | 1 |
| 9125 | R4 | 10.19 | 0.12 | 0.01 | 6 | 1 |
| 9125 | R5 | 11.65 | 1.02 | 0.09 | 1 | 2 |
| 9125 | R6 | 11.74 | 1.04 | 0.09 | 6 | 2 |
| 9125 | R7 | 10.9 | 2.37 | 0.22 | 6 | 2 |
| 9125 | R8 | 10.93 | 2.49 | 0.23 | 1 | 3 |
| 9128 | L4 | 5.4 | 6.98 | 1.29 | 6 | 5 |
| 9128 | L5 | 10.74 | 0.4 | 0.04 | 6 | 1 |
| 9128 | L6 | 11.07 | 3.62 | 0.33 | 3 | 3 |
| 9129 | L3 | 7.92 | 0.21 | 0.03 | 6 | 1 |
| 9129 | L4 | 9.94 | -0.04 | 0 | 6 | 1 |
| 9129 | L5 | 10.25 | -0.75 | -0.07 | 6 | 1 |
| 9129 | L6 | 9.97 | -1.4 | -0.14 | 6 | 1 |
| 9129 | R3 | 10.28 | -1.76 | -0.17 | 6 | 1 |
| 9129 | R4 | 7.34 | 4.41 | 0.6 | 3 | 4 |
| 9129 | R5 | 7.18 | 2.68 | 0.37 | 3 | 3 |
| 9129 | R6 | 8.12 | 4.06 | 0.5 | 3 | 4 |
| 9161 | L3 | 4.62 | 4.17 | 0.9 | 6 | 4 |
| 9161 | L4 | 9.82 | 1.6 | 0.16 | 6 | 2 |
| 9161 | L5 | 8.92 | 1.42 | 0.16 | 6 | 2 |
| 9161 | L6 | 9.04 | 0.92 | 0.1 | 6 | 2 |
| 9162 | L4 | 6.61 | 4.27 | 0.65 | 6 | 4 |
| 9162 | L5 | 6.23 | 3.65 | 0.59 | 6 | 4 |
| 9162 | L6 | 8.99 | 4.25 | 0.47 | 6 | 3 |
| 9162 | L7 | 6.5 | 1.7 | 0.26 | 6 | 3 |
| 9162 | R4 | 9.95 | 0.86 | 0.09 | 2 | 2 |
| 9162 | R5 | 10.92 | 1.32 | 0.12 | 2 | 2 |
| 9162 | R6 | 11.99 | 1.18 | 0.1 | 2 | 2 |
| 9163 | L2 | 13 | 3.95 | 0.3 | 3 | 3 |
| 9163 | L3 | 12.48 | 4.74 | 0.38 | 3 | 3 |
| 9163 | L4 | 11.57 | 4.02 | 0.35 | 3 | 3 |
| 9163 | L5 | 13.79 | 1.49 | 0.11 | 6 | 2 |
| 9163 | R3 | 11.6 | 4.1 | 0.35 | 3 | 3 |
| 9163 | R4 | 11.28 | 0.63 | 0.06 | 6 | 2 |
| 9163 | R5 | 13.04 | 1.95 | 0.15 | 2 | 2 |
| 9163 | R6 | 9.89 | 0.98 | 0.1 | 2 | 2 |
| 9164 | L4 | 11.51 | 1.14 | 0.1 | 6 | 2 |
| 9164 | L5 | 11.42 | 2.79 | 0.24 | 3 | 3 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 9164 | L6 | 10.46 | 2.15 | 0.21 | 3 | 2 |
| 9164 | L7 | 8.98 | 3.9 | 0.43 | 3 | 3 |
| 9164 | R2 | 8.08 | 3.67 | 0.45 | 3 | 3 |
| 9164 | R3 | 8.16 | 3.72 | 0.46 | 4 | 3 |
| 9164 | R4 | 8.48 | 4.6 | 0.54 | 4 | 4 |
| 9164 | R5 | 8.31 | 5.81 | 0.7 | 4 | 4 |
| 9164 | R6 | 8.15 | 4.07 | 0.5 | 4 | 4 |
| 9202 | L1 | 4.46 | 4.91 | 1.1 | 5 | 5 |
| 9202 | L2 | 6.82 | 7.55 | 1.11 | 6 | 5 |
| 9202 | L3 | 4.58 | 4.97 | 1.08 | 5 | 4 |
| 9202 | L4 | 7.06 | 7.49 | 1.06 | 6 | 5 |
| 9202 | L5 | 4.63 | 5.67 | 1.23 | 5 | 5 |
| 9202 | L6 | 7.21 | 8.97 | 1.24 | 6 | 5 |
| 9202 | L7 | 5.25 | 6.44 | 1.23 | 5 | 5 |
| 9202 | L8 | 8.07 | 9.87 | 1.22 | 6 | 5 |
| 9202 | R3 | 10.38 | 0.46 | 0.04 | 6 | 1 |
| 9202 | R4 | 9.3 | 1.01 | 0.11 | 6 | 2 |
| 9202 | R5 | 9.31 | 0.2 | 0.02 | 6 | 1 |
| 9202 | R6 | 7.82 | 0.36 | 0.05 | 6 | 1 |
| 9244 | L3 | 5.69 | 4.49 | 0.79 | 4 | 4 |
| 9244 | L4 | 6.03 | 3.47 | 0.58 | 4 | 4 |
| 9244 | L5 | 6.69 | 4.51 | 0.67 | 4 | 4 |
| 9244 | L6 | 4.9 | 2 | 0.41 | 4 | 3 |
| 9244 | R4 | 5.27 | 7.73 | 1.47 | 5 | 5 |
| 9244 | R5 | 6.68 | 6.42 | 0.96 | 5 | 4 |
| 9244 | R6 | 5.59 | 7.41 | 1.33 | 5 | 5 |
| 9244 | R7 | 2.52 | 6.36 | 2.53 | 5 | 5 |
| 9247 | L3 | 9.95 | -0.95 | -0.1 | 6 | 1 |
| 9247 | L4 | 9.02 | -0.15 | -0.02 | 6 | 1 |
| 9247 | L5 | 8.61 | 1.04 | 0.12 | 6 | 2 |
| 9247 | L6 | 6.25 | 4.21 | 0.67 | 3 | 4 |
| 9247 | R3 | 8.74 | 0.35 | 0.04 | 1 | 1 |
| 9247 | R4 | 7.67 | 1.44 | 0.19 | 1 | 3 |
| 9247 | R5 | 7.74 | 1.44 | 0.19 | 3 | 3 |
| 9247 | R6 | 10.82 | -0.42 | -0.04 | 1 | 1 |
| 9247 | R7 | 10.02 | -0.13 | -0.01 | 1 | 1 |
| 9273 | L3 | 11.43 | 2.24 | 0.2 | 2 | 2 |
| 9273 | L4 | 12.17 | 1.27 | 0.1 | 2 | 2 |
| 9273 | L5 | 11.52 | 0.47 | 0.04 | 6 | 1 |
| 9273 | L6 | 10.75 | 1.44 | 0.13 | 6 | 2 |
| 9273 | R3 | 10.49 | 2.19 | 0.21 | 3 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 9273 | R4 | 12.51 | 4.45 | 0.36 | 3 | 3 |
| 9273 | R5 | 9.98 | 3.44 | 0.34 | 3 | 3 |
| 9273 | R6 | 9.6 | 5.25 | 0.55 | 4 | 4 |
| 9274 | L3 | 12.21 | 0.13 | 0.01 | 6 | 1 |
| 9274 | L4 | 11.78 | 1.56 | 0.13 | 6 | 2 |
| 9274 | L5 | 12.23 | 3.97 | 0.32 | 3 | 3 |
| 9274 | L6 | 10.11 | 6.5 | 0.64 | 4 | 4 |
| 9274 | R3 | 11.31 | 3.24 | 0.29 | 3 | 3 |
| 9274 | R4 | 14.69 | 2.77 | 0.19 | 3 | 2 |
| 9274 | R5 | 13.59 | -0.51 | -0.04 | 6 | 1 |
| 9274 | R6 | 14.73 | 0.78 | 0.05 | 2 | 2 |
| 9284 | L2 | 10.04 | -0.29 | -0.03 | 6 | 1 |
| 9284 | L3 | 9.22 | 1.22 | 0.13 | 2 | 2 |
| 9284 | L4 | 9.2 | 1.2 | 0.13 | 6 | 2 |
| 9284 | L5 | 7.42 | 0.51 | 0.07 | 2 | 2 |
| 9284 | L6 | 7.48 | 0.54 | 0.07 | 6 | 2 |
| 9284 | L7 | 8.7 | 1.76 | 0.2 | 2 | 3 |
| 9284 | L8 | 8.61 | 1.76 | 0.2 | 6 | 3 |
| 9284 | R3 | 4.97 | 4.87 | 0.98 | 6 | 4 |
| 9284 | R4 | 5.69 | 1.96 | 0.34 | 6 | 3 |
| 9284 | R5 | 4.72 | 4.25 | 0.9 | 6 | 4 |
| 9309 | L3 | 5.69 | 4.62 | 0.81 | 4 | 4 |
| 9309 | L4 | 5.65 | 5.03 | 0.89 | 4 | 4 |
| 9309 | L5 | 6.55 | 3.69 | 0.56 | 4 | 4 |
| 9309 | L6 | 7.57 | 3.28 | 0.43 | 3 | 3 |
| 9309 | L7 | 7.67 | 3.42 | 0.45 | 4 | 3 |
| 9309 | R3 | 8.68 | 1.67 | 0.19 | 6 | 2 |
| 9309 | R4 | 11.39 | 2.23 | 0.2 | 6 | 2 |
| 9309 | R5 | 8.5 | 3.23 | 0.38 | 3 | 3 |
| 9309 | R6 | 8.54 | 3.31 | 0.39 | 6 | 3 |
| 9309 | R7 | 9.31 | 2.41 | 0.26 | 3 | 3 |
| 9309 | R8 | 9.32 | 2.42 | 0.26 | 6 | 3 |
| 9340 | L3 | 10.92 | 2.24 | 0.21 | 3 | 2 |
| 9340 | L4 | 9.95 | 0.2 | 0.02 | 6 | 1 |
| 9340 | L5 | 10.61 | -0.39 | -0.04 | 6 | 1 |
| 9340 | L6 | 8.93 | 0.94 | 0.1 | 6 | 2 |
| 9340 | R3 | 11.03 | 0.37 | 0.03 | 2 | 1 |
| 9340 | R4 | 11.17 | 0.06 | 0.01 | 2 | 1 |
| 9340 | R5 | 10.98 | -0.33 | -0.03 | 2 | 1 |
| 9340 | R6 | 10.61 | 0.82 | 0.08 | 2 | 2 |
| 9344 | L3 | 9.42 | 0.05 | 0.01 | 6 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 9344 | L4 | 10.15 | 1.18 | 0.12 | 2 | 2 |
| 9344 | L5 | 10.72 | 1.47 | 0.14 | 2 | 2 |
| 9344 | L6 | 11.09 | 0.89 | 0.08 | 2 | 2 |
| 9344 | R3 | 8.6 | -0.17 | -0.02 | 2 | 1 |
| 9344 | R4 | 9.86 | 0.35 | 0.04 | 1 | 1 |
| 9344 | R4 | 9.93 | 0.35 | 0.04 | 2 | 1 |
| 9344 | R5 | 11.15 | -0.28 | -0.03 | 1 | 1 |
| 9344 | R6 | 10.79 | -1.17 | -0.11 | 1 | 1 |
| 9347 | L3 | 9.63 | 2.01 | 0.21 | 2 | 3 |
| 9347 | L4 | 9.12 | 1.05 | 0.11 | 2 | 2 |
| 9347 | L5 | 9.71 | 1 | 0.1 | 2 | 2 |
| 9347 | L6 | 5.7 | 1.59 | 0.28 | 3 | 3 |
| 9347 | R4 | 3.67 | 2.64 | 0.72 | 4 | 4 |
| 9347 | R5 | 5.58 | 2.58 | 0.46 | 4 | 3 |
| 9347 | R6 | 10.06 | 0.24 | 0.02 | 6 | 1 |
| 9347 | R7 | 7.83 | 3.01 | 0.38 | 4 | 3 |
| 9382 | L4 | 14.3 | -1.67 | -0.12 | 1 | 1 |
| 9382 | L5 | 14.86 | -3.26 | -0.22 | 1 | 1 |
| 9382 | L6 | 12.66 | -2.75 | -0.22 | 1 | 1 |
| 9382 | L7 | 10.49 | 1.61 | 0.15 | 1 | 2 |
| 9382 | L8 | 10.42 | 1.56 | 0.15 | 3 | 2 |
| 9382 | R1 | 12.05 | -0.02 | 0 | 1 | 1 |
| 9382 | R2 | 11.98 | -0.13 | -0.01 | 6 | 1 |
| 9382 | R3 | 12.88 | 0.94 | 0.07 | 1 | 2 |
| 9382 | R4 | 12.89 | 0.98 | 0.08 | 6 | 2 |
| 9382 | R5 | 12.95 | -0.98 | -0.08 | 1 | 1 |
| 9382 | R6 | 12.98 | -1.02 | -0.08 | 6 | 1 |
| 9382 | R7 | 12.97 | -1.11 | -0.09 | 1 | 1 |
| 9382 | R8 | 13.1 | -1.1 | -0.08 | 6 | 1 |
| 9411 | L3 | 11.69 | 1.39 | 0.12 | 3 | 2 |
| 9411 | L4 | 11.23 | 0.36 | 0.03 | 6 | 1 |
| 9411 | L5 | 11.42 | 0.73 | 0.06 | 6 | 2 |
| 9411 | L6 | 11.42 | 1.55 | 0.14 | 6 | 2 |
| 9411 | R2 | 11.17 | 2.51 | 0.22 | 2 | 3 |
| 9411 | R3 | 11.12 | 2.59 | 0.23 | 3 | 3 |
| 9411 | R4 | 13.32 | 0.2 | 0.02 | 2 | 1 |
| 9411 | R5 | 12.03 | 1.68 | 0.14 | 2 | 2 |
| 9411 | R6 | 8.54 | 0.04 | 0 | 6 | 1 |
| 9467 | L3 | 8.87 | 0.15 | 0.02 | 6 | 1 |
| 9467 | L4 | 9.71 | 0.63 | 0.06 | 2 | 2 |
| 9467 | L5 | 12.05 | 1.8 | 0.15 | 2 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 9467 | L6 | 10.85 | 1.84 | 0.17 | 2 | 2 |
| 9467 | R4 | 5.64 | 5.83 | 1.03 | 5 | 4 |
| 9467 | R5 | 4.45 | 6.44 | 1.45 | 5 | 5 |
| 9467 | R6 | 6.76 | 5.53 | 0.82 | 5 | 4 |
| 9467 | R7 | 6.65 | 4.43 | 0.67 | 5 | 4 |
| 9479 | L4 | 8.37 | 3.99 | 0.48 | 4 | 3 |
| 9479 | L5 | 8.86 | 2.43 | 0.27 | 6 | 3 |
| 9479 | L6 | 9.05 | 3.35 | 0.37 | 6 | 3 |
| 9479 | L7 | 9.05 | 2.66 | 0.29 | 6 | 3 |
| 9479 | R3 | 8.85 | 4.42 | 0.5 | 3 | 4 |
| 9479 | R4 | 8.45 | 3.48 | 0.41 | 3 | 3 |
| 9479 | R5 | 9.11 | 4.79 | 0.53 | 3 | 4 |
| 9479 | R6 | 9.68 | 1.84 | 0.19 | 3 | 2 |
| 9559 | L3 | 10.89 | 0.98 | 0.09 | 2 | 2 |
| 9559 | L4 | 12.27 | -0.74 | -0.06 | 6 | 1 |
| 9559 | L5 | 11.16 | 0.3 | 0.03 | 2 | 1 |
| 9559 | L6 | 9.43 | 0.37 | 0.04 | 2 | 1 |
| 9559 | R3 | 10.02 | -0.8 | -0.08 | 1 | 1 |
| 9559 | R4 | 10.31 | -0.29 | -0.03 | 1 | 1 |
| 9559 | R5 | 11.06 | -0.91 | -0.08 | 1 | 1 |
| 9559 | R6 | 9.14 | -0.07 | -0.01 | 1 | 1 |
| 9606 | L3 | 5.64 | 5.01 | 0.89 | 4 | 4 |
| 9606 | L4 | 7.11 | 5.98 | 0.84 | 4 | 4 |
| 9606 | L5 | 6.55 | 6.3 | 0.96 | 4 | 4 |
| 9606 | L6 | 4.02 | 5.03 | 1.25 | 4 | 5 |
| 9606 | R2 | 3.5 | 7.79 | 2.23 | 4 | 5 |
| 9606 | R3 | 3.32 | 7.79 | 2.35 | 4 | 5 |
| 9606 | R4 | 7.63 | 2.64 | 0.35 | 3 | 3 |
| 9606 | R5 | 9.35 | 1.31 | 0.14 | 3 | 2 |
| 9700 | L2 | 12.77 | 0.51 | 0.04 | 6 | 1 |
| 9700 | L3 | 10.91 | 2.34 | 0.21 | 6 | 2 |
| 9700 | L4 | 12.78 | 1.54 | 0.12 | 6 | 2 |
| 9700 | L5 | 12.93 | -0.29 | -0.02 | 6 | 1 |
| 9700 | R1 | 5.11 | 8.76 | 1.71 | 5 | 5 |
| 9700 | R2 | 5.27 | 8.86 | 1.68 | 6 | 5 |
| 9700 | R3 | 6.83 | 9.65 | 1.41 | 5 | 5 |
| 9700 | R4 | 6.7 | 9.73 | 1.45 | 6 | 5 |
| 9700 | R5 | 7.8 | 10.36 | 1.33 | 5 | 5 |
| 9700 | R6 | 7.76 | 10.39 | 1.34 | 6 | 5 |
| 9700 | R7 | 6.79 | 7.47 | 1.1 | 5 | 5 |
| 9700 | R8 | 6.75 | 7.44 | 1.1 | 6 | 5 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 9702 | L1 | 4.74 | 7.51 | 1.59 | 4 | 5 |
| 9702 | L2 | 5.11 | 6.61 | 1.29 | 4 | 5 |
| 9702 | L3 | 5.54 | 5.74 | 1.04 | 4 | 4 |
| 9702 | R1 | 11.46 | 0.92 | 0.08 | 6 | 2 |
| 9702 | R2 | 9.78 | 1.31 | 0.13 | 6 | 2 |
| 9702 | R3 | 9 | 1.05 | 0.12 | 6 | 2 |
| 9702 | R4 | 7.12 | 0.53 | 0.07 | 6 | 2 |
| 9713 | L2 | 7.91 | 2.16 | 0.27 | 6 | 3 |
| 9713 | L3 | 6.46 | 1.99 | 0.31 | 6 | 3 |
| 9713 | L4 | 11.14 | 3.84 | 0.34 | 6 | 3 |
| 9713 | L5 | 9.29 | 5.92 | 0.64 | 5 | 4 |
| 9713 | R4 | 11.15 | -0.18 | -0.02 | 6 | 1 |
| 9713 | R5 | 12.02 | -1.06 | -0.09 | 6 | 1 |
| 9713 | R6 | 8.29 | -0.55 | -0.07 | 6 | 1 |
| 9713 | R7 | 6.66 | 0.28 | 0.04 | 6 | 1 |
| 9733 | L2 | 8.95 | -1.2 | -0.13 | 1 | 1 |
| 9733 | L3 | 10.2 | 0.35 | 0.03 | 1 | 1 |
| 9733 | L4 | 10.79 | 0.28 | 0.03 | 1 | 1 |
| 9733 | L5 | 10.12 | 1.51 | 0.15 | 1 | 2 |
| 9733 | R2 | 9.75 | 0.95 | 0.1 | 1 | 2 |
| 9733 | R3 | 10.89 | 0.24 | 0.02 | 1 | 1 |
| 9733 | R4 | 11.15 | -0.45 | -0.04 | 1 | 1 |
| 9733 | R5 | 11.15 | 1.03 | 0.09 | 1 | 2 |
| 9872 | L3 | 5.55 | 5.85 | 1.05 | 5 | 5 |
| 9872 | L3 | 5.67 | 6.03 | 1.06 | 6 | 5 |
| 9872 | L4 | 5.55 | 7.43 | 1.34 | 5 | 5 |
| 9872 | L4 | 5.47 | 7.44 | 1.36 | 6 | 5 |
| 9872 | L5 | 5.55 | 8.42 | 1.52 | 5 | 5 |
| 9872 | L5 | 5.57 | 8.46 | 1.52 | 6 | 5 |
| 9872 | L6 | 6.32 | 5.13 | 0.81 | 5 | 4 |
| 9872 | L6 | 6.47 | 5.33 | 0.82 | 6 | 4 |
| 9872 | R3 | 11.83 | 0.99 | 0.08 | 6 | 2 |
| 9872 | R4 | 10.47 | 0.99 | 0.09 | 6 | 2 |
| 9872 | R5 | 11.33 | 0.99 | 0.09 | 6 | 2 |
| 9872 | R6 | 10.74 | 0.23 | 0.02 | 6 | 1 |
| 9873 | L4 | 9.18 | 0.18 | 0.02 | 1 | 1 |
| 9873 | L5 | 9.73 | 0.91 | 0.09 | 1 | 2 |
| 9873 | L6 | 9.48 | 1.06 | 0.11 | 1 | 2 |
| 9873 | L7 | 10.01 | 0.79 | 0.08 | 1 | 2 |
| 9873 | R2 | 10.65 | 0.37 | 0.03 | 1 | 1 |
| 9873 | R2 | 10.61 | 0.42 | 0.04 | 6 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 9873 | R3 | 11.36 | 0.1 | 0.01 | 1 | 1 |
| 9873 | R3 | 11.4 | 0.07 | 0.01 | 6 | 1 |
| 9873 | R4 | 10.23 | -0.44 | -0.04 | 1 | 1 |
| 9873 | R4 | 10.33 | -0.53 | -0.05 | 6 | 1 |
| 9873 | R5 | 9.53 | 0.06 | 0.01 | 1 | 1 |
| 9873 | R5 | 9.46 | -0.02 | 0 | 6 | 1 |
| 9903 | L3 | 7.23 | 1.55 | 0.21 | 3 | 3 |
| 9903 | L4 | 6 | -0.15 | -0.03 | 1 | 1 |
| 9903 | L5 | 6.9 | 0.41 | 0.06 | 1 | 1 |
| 9903 | L6 | 7.06 | -0.33 | -0.05 | 1 | 1 |
| 9903 | R2 | 8.21 | 3.03 | 0.37 | 4 | 3 |
| 9903 | R3 | 8.22 | 3.13 | 0.38 | 6 | 3 |
| 9903 | R4 | 7.57 | 4.3 | 0.57 | 4 | 4 |
| 9903 | R5 | 7.57 | 4.28 | 0.57 | 6 | 4 |
| 9903 | R6 | 6.4 | 3.85 | 0.6 | 4 | 4 |
| 9903 | R7 | 6.43 | 3.85 | 0.6 | 6 | 4 |
| 9903 | R7 | 5.57 | 3.44 | 0.62 | 4 | 4 |
| 9903 | R8 | 5.63 | 3.45 | 0.61 | 6 | 4 |
| 9910 | L2 | 10.04 | 0.2 | 0.02 | 6 | 1 |
| 9910 | L3 | 10.25 | 0.19 | 0.02 | 6 | 1 |
| 9910 | L4 | 8.45 | 0.46 | 0.05 | 2 | 1 |
| 9910 | L5 | 10.34 | 1.1 | 0.11 | 2 | 2 |
| 9910 | L6 | 8.59 | 0.09 | 0.01 | 6 | 1 |
| 9910 | R3 | 9.12 | 0.81 | 0.09 | 2 | 2 |
| 9910 | R3 | 9.12 | 0.83 | 0.09 | 6 | 2 |
| 9910 | R4 | 9.33 | 0.69 | 0.07 | 2 | 2 |
| 9910 | R4 | 9.25 | 0.61 | 0.07 | 6 | 2 |
| 9910 | R5 | 8.71 | 1.23 | 0.14 | 2 | 2 |
| 9910 | R5 | 8.75 | 1.18 | 0.13 | 6 | 2 |
| 9910 | R6 | 11.33 | 1.12 | 0.1 | 2 | 2 |
| 9910 | R6 | 11.32 | 1.15 | 0.1 | 6 | 2 |
| 9919 | L3 | 10.97 | -1 | -0.09 | 1 | 1 |
| 9919 | L4 | 9.37 | 0.49 | 0.05 | 1 | 2 |
| 9919 | L5 | 10.06 | -1.35 | -0.13 | 1 | 1 |
| 9919 | L6 | 9.21 | 1.15 | 0.12 | 1 | 2 |
| 9919 | R3 | 10.54 | -0.8 | -0.08 | 1 | 1 |
| 9919 | R4 | 13.27 | -0.78 | -0.06 | 1 | 1 |
| 9919 | R5 | 11.39 | -0.25 | -0.02 | 1 | 1 |
| 9919 | R6 | 10.31 | 0.88 | 0.08 | 1 | 2 |
| 9938 | L2 | 5.33 | 0.3 | 0.06 | 2 | 1 |
| 9938 | L3 | 5.35 | 0.35 | 0.07 | 3 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 9938 | L4 | 5.93 | -0.02 | 0 | 2 | 1 |
| 9938 | L5 | 6.23 | -0.38 | -0.06 | 6 | 1 |
| 9938 | L6 | 7.58 | 0.56 | 0.07 | 6 | 2 |
| 9938 | R4 | 4.29 | 5.67 | 1.32 | 6 | 5 |
| 9938 | R5 | 3.35 | 4.71 | 1.41 | 6 | 5 |
| 9938 | R6 | 6.6 | 4.07 | 0.62 | 4 | 4 |
| 9938 | R7 | 4.27 | 3.83 | 0.9 | 4 | 4 |
| 9945 | L3 | 7.14 | 1.51 | 0.21 | 3 | 3 |
| 9945 | L4 | 6.48 | 2.89 | 0.45 | 3 | 3 |
| 9945 | L5 | 6.54 | 2.97 | 0.45 | 4 | 3 |
| 9945 | L6 | 5.9 | 3.8 | 0.64 | 4 | 4 |
| 9945 | L7 | 6.73 | 2.48 | 0.37 | 3 | 3 |
| 9945 | L8 | 6.75 | 2.55 | 0.38 | 4 | 3 |
| 9945 | R5 | 7.67 | 4.13 | 0.54 | 4 | 4 |
| 9945 | R6 | 7.46 | 4.36 | 0.58 | 4 | 4 |
| 9945 | R7 | 7.35 | 4.5 | 0.61 | 4 | 4 |
| 9945 | R8 | 5.75 | 3.99 | 0.69 | 4 | 4 |
| 9984 | L2 | 9.49 | 1.77 | 0.19 | 1 | 2 |
| 9984 | L3 | 9.92 | 1.2 | 0.12 | 1 | 2 |
| 9984 | L4 | 10.81 | 0.58 | 0.05 | 1 | 2 |
| 9984 | L5 | 11.9 | 0.89 | 0.07 | 1 | 2 |
| 9984 | R4 | 5.09 | 8.09 | 1.59 | 6 | 5 |
| 9984 | R5 | 6.57 | 8.09 | 1.23 | 6 | 5 |
| 9984 | R6 | 9.38 | 6.75 | 0.72 | 6 | 4 |
| 9984 | R7 | 5.8 | 7.1 | 1.23 | 6 | 5 |
| 9985 | L4 | 4.93 | 2.71 | 0.55 | 6 | 4 |
| 9985 | L5 | 6.11 | 3.06 | 0.5 | 6 | 4 |
| 9985 | L6 | 5.42 | 4.72 | 0.87 | 6 | 4 |
| 9985 | R4 | 3.7 | 3.49 | 0.94 | 6 | 4 |
| 9985 | R5 | 5.31 | 4.29 | 0.81 | 6 | 4 |
| 9985 | R6 | 6.92 | 5.27 | 0.76 | 6 | 4 |
| 9988 | L3 | 9.3 | -0.11 | -0.01 | 1 | 1 |
| 9988 | L4 | 10.25 | 0.62 | 0.06 | 1 | 2 |
| 9988 | L5 | 10.43 | 0.18 | 0.02 | 1 | 1 |
| 9988 | L6 | 10.09 | 0.25 | 0.03 | 1 | 1 |
| 9988 | R2 | 10.29 | -0.51 | -0.05 | 1 | 1 |
| 9988 | R3 | 9.44 | -1.24 | -0.13 | 1 | 1 |
| 9988 | R4 | 9.36 | -0.03 | 0 | 1 | 1 |
| 9988 | R5 | 9.36 | -0.5 | -0.05 | 1 | 1 |
| 10047 | L2 | 9.73 | 0.64 | 0.07 | 6 | 2 |
| 10047 | L3 | 11.55 | 0.49 | 0.04 | 6 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10047 | L4 | 11.34 | -0.06 | -0.01 | 6 | 1 |
| 10047 | L5 | 11.45 | -0.17 | -0.01 | 6 | 1 |
| 10047 | L6 | 10.3 | 0.12 | 0.01 | 6 | 1 |
| 10047 | R4 | 11.49 | -0.09 | -0.01 | 6 | 1 |
| 10047 | R5 | 12.1 | -0.39 | -0.03 | 6 | 1 |
| 10047 | R6 | 11.89 | -0.56 | -0.05 | 6 | 1 |
| 10047 | R7 | 9.44 | 1.53 | 0.16 | 3 | 2 |
| 10048 | R4 | 9.49 | -1.8 | -0.19 | 6 | 1 |
| 10048 | R5 | 9.63 | -1.26 | -0.13 | 6 | 1 |
| 10048 | R6 | 9.75 | -0.71 | -0.07 | 6 | 1 |
| 10048 | R7 | 8.63 | -1.89 | -0.22 | 6 | 1 |
| 10050 | L3 | 4.13 | 5.93 | 1.43 | 5 | 5 |
| 10050 | L4 | 4.82 | 6.76 | 1.4 | 5 | 5 |
| 10050 | L5 | 4.82 | 6.42 | 1.33 | 5 | 5 |
| 10050 | L6 | 4.72 | 5.37 | 1.14 | 5 | 5 |
| 10050 | R3 | 3.8 | 5.92 | 1.56 | 5 | 5 |
| 10050 | R4 | 3.98 | 7.66 | 1.92 | 5 | 5 |
| 10050 | R5 | 5.27 | 8.71 | 1.65 | 5 | 5 |
| 10050 | R6 | 7.29 | 8.18 | 1.12 | 5 | 5 |
| 10071 | L2 | 10.37 | 0.65 | 0.06 | 6 | 2 |
| 10071 | L3 | 9.77 | 1.23 | 0.13 | 6 | 2 |
| 10071 | L4 | 9.95 | 1.42 | 0.14 | 6 | 2 |
| 10071 | L5 | 9.7 | 1.83 | 0.19 | 3 | 2 |
| 10071 | R4 | 9.35 | 2.59 | 0.28 | 6 | 3 |
| 10071 | R5 | 9.75 | 3.3 | 0.34 | 6 | 3 |
| 10071 | R6 | 7.97 | 4.45 | 0.56 | 4 | 4 |
| 10071 | R7 | 10.36 | 3.97 | 0.38 | 6 | 3 |
| 10110 | L3 | 6.08 | 0.98 | 0.16 | 6 | 3 |
| 10110 | L4 | 3.58 | 1.5 | 0.42 | 6 | 3 |
| 10110 | L5 | 6.67 | 2.47 | 0.37 | 3 | 3 |
| 10110 | L6 | 5.76 | 4.05 | 0.7 | 6 | 4 |
| 10110 | R3 | 6 | 8.14 | 1.36 | 5 | 5 |
| 10110 | R4 | 6.39 | 7.56 | 1.18 | 5 | 5 |
| 10110 | R5 | 3.72 | 8.62 | 2.32 | 5 | 5 |
| 10110 | R6 | 4.87 | 5.3 | 1.09 | 5 | 5 |
| 10110 | R7 | 4.78 | 6.13 | 1.28 | 5 | 5 |
| 10112 | L3 | 6.57 | 4.76 | 0.72 | 4 | 4 |
| 10112 | L4 | 6.69 | 5.31 | 0.79 | 4 | 4 |
| 10112 | L5 | 4.05 | 6.01 | 1.48 | 4 | 5 |
| 10112 | L6 | 3.22 | 6.55 | 2.03 | 4 | 5 |
| 10112 | R3 | 4.2 | 2.1 | 0.5 | 6 | 3 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10112 | R4 | 4.4 | 3.57 | 0.81 | 6 | 4 |
| 10112 | R5 | 9.93 | 0.09 | 0.01 | 6 | 1 |
| 10112 | R6 | 11.96 | 0.55 | 0.05 | 2 | 2 |
| 10133 | L3 | 7.38 | 6.96 | 0.94 | 5 | 4 |
| 10133 | L4 | 5.05 | 8.6 | 1.7 | 5 | 5 |
| 10133 | L5 | 4.72 | 8.34 | 1.77 | 5 | 5 |
| 10133 | L6 | 5.39 | 8.92 | 1.65 | 5 | 5 |
| 10133 | R3 | 7.88 | 6.14 | 0.78 | 6 | 4 |
| 10133 | R4 | 9.97 | 3.55 | 0.36 | 6 | 3 |
| 10133 | R5 | 9.94 | 3.7 | 0.37 | 6 | 3 |
| 10133 | R6 | 6.09 | 5.87 | 0.96 | 6 | 4 |
| 10140 | L4 | 4.42 | 6.09 | 1.38 | 5 | 5 |
| 10140 | L5 | 5.29 | 5.55 | 1.05 | 5 | 4 |
| 10140 | L6 | 4.95 | 6.57 | 1.33 | 5 | 5 |
| 10140 | L7 | 4.53 | 6.06 | 1.34 | 5 | 5 |
| 10140 | R4 | 5.07 | 6.89 | 1.36 | 5 | 5 |
| 10140 | R5 | 5.29 | 7 | 1.32 | 5 | 5 |
| 10140 | R6 | 7.03 | 6.08 | 0.86 | 5 | 4 |
| 10140 | R7 | 3.49 | 5.73 | 1.64 | 5 | 5 |
| 10141 | L3 | 9.71 | 1.41 | 0.14 | 2 | 2 |
| 10141 | L4 | 11.59 | 1.85 | 0.16 | 2 | 2 |
| 10141 | L5 | 9.01 | 0.37 | 0.04 | 6 | 1 |
| 10141 | L6 | 7.23 | -0.73 | -0.1 | 6 | 1 |
| 10141 | R5 | 6.91 | 5.88 | 0.85 | 4 | 4 |
| 10141 | R6 | 7.75 | 5.53 | 0.71 | 4 | 4 |
| 10141 | R7 | 7.41 | 5.28 | 0.71 | 4 | 4 |
| 10141 | R8 | 6.83 | 5.11 | 0.75 | 4 | 4 |
| 10174 | L3 | 8.28 | 3.1 | 0.37 | 3 | 3 |
| 10174 | L3 | 8.3 | 2.99 | 0.36 | 6 | 3 |
| 10174 | L4 | 6.69 | 3.34 | 0.5 | 3 | 4 |
| 10174 | L4 | 6.65 | 3.55 | 0.53 | 4 | 4 |
| 10174 | L4 | 6.84 | 3.42 | 0.5 | 6 | 4 |
| 10174 | L5 | 8.3 | 4.85 | 0.58 | 3 | 4 |
| 10174 | L5 | 8.22 | 4.79 | 0.58 | 4 | 4 |
| 10174 | L5 | 8.26 | 4.87 | 0.59 | 6 | 4 |
| 10174 | L6 | 5.73 | 3.21 | 0.56 | 3 | 4 |
| 10174 | L6 | 5.53 | 3.06 | 0.55 | 4 | 4 |
| 10174 | L6 | 5.64 | 3.08 | 0.55 | 6 | 4 |
| 10174 | R3 | 11.15 | 4.72 | 0.42 | 3 | 3 |
| 10174 | R4 | 11.14 | 4.77 | 0.43 | 4 | 3 |
| 10174 | R5 | 10.07 | 3.52 | 0.35 | 3 | 3 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10174 | R6 | 10.99 | 1.14 | 0.1 | 6 | 2 |
| 10174 | R7 | 10.8 | 0.5 | 0.05 | 6 | 1 |
| 10176 | L2 | 8.05 | -0.32 | -0.04 | 1 | 1 |
| 10176 | L3 | 10.28 | -0.75 | -0.07 | 1 | 1 |
| 10176 | L4 | 10.87 | 0.2 | 0.02 | 1 | 1 |
| 10176 | L5 | 10.78 | -0.02 | 0 | 2 | 1 |
| 10176 | L6 | 9.26 | 0.6 | 0.06 | 2 | 2 |
| 10176 | L7 | 9.17 | 1.65 | 0.18 | 2 | 2 |
| 10176 | R3 | 7.75 | 0.97 | 0.12 | 2 | 2 |
| 10176 | R4 | 8.73 | 0.76 | 0.09 | 1 | 2 |
| 10176 | R5 | 8.69 | 0.63 | 0.07 | 2 | 2 |
| 10176 | R6 | 6.83 | -0.4 | -0.06 | 1 | 1 |
| 10176 | R7 | 7.2 | 0.46 | 0.06 | 1 | 1 |
| 10233 | L3 | 9.74 | -1.21 | -0.12 | 6 | 1 |
| 10233 | L4 | 10.84 | -0.76 | -0.07 | 6 | 1 |
| 10233 | L5 | 12.6 | -0.11 | -0.01 | 6 | 1 |
| 10233 | L6 | 11.74 | 0.24 | 0.02 | 2 | 1 |
| 10233 | R2 | 12.84 | 2.67 | 0.21 | 3 | 2 |
| 10233 | R3 | 12.43 | -0.9 | -0.07 | 6 | 1 |
| 10233 | R4 | 13.22 | -1.01 | -0.08 | 6 | 1 |
| 10233 | R5 | 12.14 | -0.52 | -0.04 | 6 | 1 |
| 10254 | L4 | 9.15 | 0.28 | 0.03 | 6 | 1 |
| 10254 | L5 | 9.79 | -0.41 | -0.04 | 6 | 1 |
| 10254 | L6 | 11.06 | -0.08 | -0.01 | 6 | 1 |
| 10254 | L7 | 8.41 | 0.14 | 0.02 | 6 | 1 |
| 10254 | R3 | 9.36 | 0.77 | 0.08 | 2 | 2 |
| 10254 | R4 | 10.68 | 0.96 | 0.09 | 2 | 2 |
| 10254 | R5 | 10.79 | -0.47 | -0.04 | 6 | 1 |
| 10254 | R6 | 9.9 | -0.69 | -0.07 | 6 | 1 |
| 10282 | L2 | 5.71 | 3.26 | 0.57 | 3 | 4 |
| 10282 | L3 | 6.85 | 2.82 | 0.41 | 3 | 3 |
| 10282 | L4 | 7.32 | 4.13 | 0.56 | 3 | 4 |
| 10282 | L5 | 8.32 | 4.77 | 0.57 | 3 | 4 |
| 10282 | R3 | 7.96 | -0.47 | -0.06 | 6 | 1 |
| 10282 | R4 | 7.79 | 2.22 | 0.28 | 6 | 3 |
| 10282 | R5 | 10.48 | 1.41 | 0.13 | 2 | 2 |
| 10282 | R6 | 10.24 | 0.45 | 0.04 | 2 | 1 |
| 10284 | L3 | 9.82 | 0.78 | 0.08 | 6 | 2 |
| 10284 | L4 | 9.94 | 0.72 | 0.07 | 6 | 2 |
| 10284 | L5 | 9.18 | -0.39 | -0.04 | 6 | 1 |
| 10284 | L6 | 10.1 | 0.9 | 0.09 | 6 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10284 | R4 | 9.52 | -0.63 | -0.07 | 1 | 1 |
| 10284 | R5 | 10.6 | -1.14 | -0.11 | 1 | 1 |
| 10284 | R6 | 11.46 | 0.57 | 0.05 | 1 | 2 |
| 10284 | R7 | 11.66 | -0.31 | -0.03 | 1 | 1 |
| 10315 | L2 | 10.57 | 4.19 | 0.4 | 4 | 3 |
| 10315 | L3 | 10.09 | 5.91 | 0.59 | 4 | 4 |
| 10315 | L4 | 8.53 | 5.75 | 0.67 | 4 | 4 |
| 10315 | L5 | 8.05 | 5.59 | 0.69 | 4 | 4 |
| 10315 | R3 | 6.87 | 5.74 | 0.83 | 4 | 4 |
| 10315 | R4 | 9.12 | 4.84 | 0.53 | 4 | 4 |
| 10315 | R5 | 10.56 | 4.58 | 0.43 | 3 | 3 |
| 10315 | R6 | 10.62 | 4.69 | 0.44 | 4 | 3 |
| 10315 | R7 | 10.12 | 5.06 | 0.5 | 3 | 4 |
| 10315 | R8 | 10.14 | 5.07 | 0.5 | 4 | 4 |
| 10346 | L3 | 7.89 | 5.01 | 0.63 | 4 | 4 |
| 10346 | L3 | 7.96 | 5.16 | 0.65 | 6 | 4 |
| 10346 | L4 | 8.83 | 4.98 | 0.56 | 4 | 4 |
| 10346 | L4 | 8.84 | 4.99 | 0.56 | 6 | 4 |
| 10346 | L5 | 8.7 | 5.19 | 0.6 | 4 | 4 |
| 10346 | L5 | 8.72 | 5.1 | 0.59 | 6 | 4 |
| 10346 | L6 | 7.04 | 5.15 | 0.73 | 4 | 4 |
| 10346 | L6 | 7.07 | 5.21 | 0.74 | 6 | 4 |
| 10346 | R3 | 4.98 | 2.06 | 0.41 | 6 | 3 |
| 10346 | R4 | 11.3 | 2.84 | 0.25 | 6 | 3 |
| 10346 | R5 | 3.28 | 6.82 | 2.08 | 5 | 5 |
| 10346 | R6 | 7.49 | 5.3 | 0.71 | 5 | 4 |
| 10354 | L3 | 9.72 | -0.71 | -0.07 | 1 | 1 |
| 10354 | L3 | 9.79 | -0.63 | -0.06 | 6 | 1 |
| 10354 | L4 | 9.95 | 0.09 | 0.01 | 1 | 1 |
| 10354 | L4 | 9.95 | 0.09 | 0.01 | 6 | 1 |
| 10354 | L5 | 10.35 | 0.43 | 0.04 | 1 | 1 |
| 10354 | L5 | 10.26 | 0.6 | 0.06 | 2 | 2 |
| 10354 | L5 | 10.42 | 0.69 | 0.07 | 6 | 2 |
| 10354 | L6 | 10.04 | 1.84 | 0.18 | 2 | 2 |
| 10354 | L6 | 10.08 | 1.82 | 0.18 | 6 | 2 |
| 10354 | R5 | 9.04 | 1.29 | 0.14 | 2 | 2 |
| 10354 | R5 | 9.04 | 1.33 | 0.15 | 6 | 2 |
| 10354 | R6 | 9.89 | 0.35 | 0.03 | 1 | 1 |
| 10354 | R6 | 9.88 | 0.39 | 0.04 | 2 | 1 |
| 10354 | R6 | 9.91 | 0.36 | 0.04 | 6 | 1 |
| 10354 | R7 | 11.44 | -0.72 | -0.06 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10354 | R7 | 11.51 | -0.77 | -0.07 | 6 | 1 |
| 10354 | R8 | 9.98 | -1.26 | -0.13 | 1 | 1 |
| 10354 | R8 | 9.97 | -1.32 | -0.13 | 6 | 1 |
| 10369 | L2 | 9.32 | 0.39 | 0.04 | 1 | 1 |
| 10369 | L3 | 10.82 | -0.46 | -0.04 | 1 | 1 |
| 10369 | L4 | 10.92 | 0.07 | 0.01 | 1 | 1 |
| 10369 | L5 | 11.89 | 0.02 | 0 | 1 | 1 |
| 10369 | R4 | 13.35 | -1.93 | -0.14 | 6 | 1 |
| 10369 | R5 | 11.56 | -0.35 | -0.03 | 6 | 1 |
| 10369 | R6 | 11.2 | -1.1 | -0.1 | 6 | 1 |
| 10369 | R7 | 11.66 | -1.23 | -0.11 | 6 | 1 |
| 10392 | L3 | 6.68 | 4.06 | 0.61 | 4 | 4 |
| 10392 | L3 | 6.68 | 4.01 | 0.6 | 6 | 4 |
| 10392 | L4 | 7.98 | 3.99 | 0.5 | 4 | 4 |
| 10392 | L4 | 7.95 | 3.98 | 0.5 | 6 | 4 |
| 10392 | L5 | 7.98 | 5.32 | 0.67 | 4 | 4 |
| 10392 | L5 | 8.03 | 5.49 | 0.68 | 6 | 4 |
| 10392 | L6 | 7.5 | 6.37 | 0.85 | 4 | 4 |
| 10392 | L6 | 7.55 | 6.4 | 0.85 | 6 | 4 |
| 10392 | R3 | 7.27 | 4.55 | 0.63 | 4 | 4 |
| 10392 | R3 | 7.27 | 4.48 | 0.62 | 6 | 4 |
| 10392 | R4 | 6.87 | 3.22 | 0.47 | 4 | 3 |
| 10392 | R4 | 6.89 | 3.73 | 0.54 | 6 | 4 |
| 10392 | R5 | 7.7 | 1.25 | 0.16 | 3 | 2 |
| 10392 | R5 | 7.65 | 1.24 | 0.16 | 6 | 2 |
| 10392 | R6 | 6.61 | 1.38 | 0.21 | 3 | 3 |
| 10392 | R6 | 6.62 | 1.44 | 0.22 | 6 | 3 |
| 10399 | L4 | 10.55 | -0.56 | -0.05 | 6 | 1 |
| 10399 | L5 | 10.45 | 1.07 | 0.1 | 6 | 2 |
| 10399 | L6 | 10.92 | 1.94 | 0.18 | 6 | 2 |
| 10399 | L7 | 9.18 | 1.13 | 0.12 | 6 | 2 |
| 10399 | R3 | 9.7 | 2.91 | 0.3 | 6 | 3 |
| 10399 | R4 | 8.9 | 4.94 | 0.56 | 4 | 4 |
| 10399 | R5 | 9 | 5.08 | 0.56 | 6 | 4 |
| 10399 | R6 | 9.14 | 4.08 | 0.45 | 4 | 3 |
| 10399 | R7 | 9.15 | 4.07 | 0.44 | 6 | 3 |
| 10399 | R8 | 9.88 | 4.94 | 0.5 | 4 | 4 |
| 10399 | R9 | 9.89 | 4.95 | 0.5 | 6 | 4 |
| 10423 | L2 | 8.08 | -1 | -0.12 | 6 | 1 |
| 10423 | L3 | 9.58 | 0.16 | 0.02 | 1 | 1 |
| 10423 | L4 | 10.71 | 0 | 0 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10423 | L5 | 10.62 | -0.03 | 0 | 1 | 1 |
| 10423 | L6 | 11.7 | 1.29 | 0.11 | 1 | 2 |
| 10423 | R3 | 9.6 | 0 | 0 | 1 | 1 |
| 10423 | R4 | 10.82 | -1.48 | -0.14 | 1 | 1 |
| 10423 | R5 | 9.74 | -1.57 | -0.16 | 1 | 1 |
| 10423 | R6 | 9.54 | -0.39 | -0.04 | 1 | 1 |
| 10445 | L3 | 9.69 | -0.64 | -0.07 | 1 | 1 |
| 10445 | L4 | 11.26 | -0.55 | -0.05 | 1 | 1 |
| 10445 | L5 | 11.39 | -1.7 | -0.15 | 1 | 1 |
| 10445 | L6 | 10.7 | -0.43 | -0.04 | 1 | 1 |
| 10445 | R3 | 9.76 | -0.19 | -0.02 | 6 | 1 |
| 10445 | R4 | 9.76 | -0.83 | -0.09 | 6 | 1 |
| 10445 | R5 | 10.2 | -1.12 | -0.11 | 6 | 1 |
| 10445 | R6 | 9.7 | -0.49 | -0.05 | 6 | 1 |
| 10447 | L3 | 4.55 | 2.28 | 0.5 | 6 | 3 |
| 10447 | L4 | 8.99 | 1.05 | 0.12 | 6 | 2 |
| 10447 | L5 | 7.95 | 5 | 0.63 | 4 | 4 |
| 10447 | L6 | 8.54 | 5.78 | 0.68 | 4 | 4 |
| 10447 | R4 | 9.72 | 5.19 | 0.53 | 4 | 4 |
| 10447 | R5 | 7.74 | 1.04 | 0.13 | 6 | 2 |
| 10447 | R6 | 6.75 | 2.42 | 0.36 | 6 | 3 |
| 10485 | L3 | 11.1 | -0.9 | -0.08 | 1 | 1 |
| 10485 | L4 | 10.92 | -1.57 | -0.14 | 1 | 1 |
| 10485 | L5 | 11.29 | -0.84 | -0.07 | 1 | 1 |
| 10485 | L6 | 11.68 | 1.48 | 0.13 | 1 | 2 |
| 10485 | R3 | 7.75 | 2.68 | 0.35 | 6 | 3 |
| 10485 | R4 | 9.44 | 3.52 | 0.37 | 6 | 3 |
| 10485 | R5 | 10.83 | 0.77 | 0.07 | 1 | 2 |
| 10485 | R6 | 9.96 | 0.81 | 0.08 | 1 | 2 |
| 10491 | L3 | 8.97 | 0.11 | 0.01 | 6 | 1 |
| 10491 | L4 | 9.21 | 0.53 | 0.06 | 6 | 2 |
| 10491 | L5 | 8.82 | 0.75 | 0.08 | 6 | 2 |
| 10491 | L6 | 7.8 | 3.36 | 0.43 | 3 | 3 |
| 10491 | R3 | 8.9 | 3.17 | 0.36 | 3 | 3 |
| 10491 | R4 | 9.55 | 0.92 | 0.1 | 6 | 2 |
| 10491 | R5 | 10.42 | 1.22 | 0.12 | 6 | 2 |
| 10491 | R6 | 9.39 | 1.5 | 0.16 | 6 | 2 |
| 10495 | L3 | 9.92 | 1.28 | 0.13 | 2 | 2 |
| 10495 | L4 | 11.09 | 0.32 | 0.03 | 2 | 1 |
| 10495 | L5 | 10.4 | 0.25 | 0.02 | 6 | 1 |
| 10495 | L6 | 8.96 | 2.16 | 0.24 | 6 | 3 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10495 | R3 | 9.85 | 0.48 | 0.05 | 2 | 1 |
| 10495 | R4 | 9.85 | 0.62 | 0.06 | 2 | 2 |
| 10495 | R5 | 10.12 | -0.49 | -0.05 | 2 | 1 |
| 10495 | R6 | 9.57 | 0.48 | 0.05 | 2 | 1 |
| 10515 | R5 | 11.52 | 1.74 | 0.15 | 6 | 2 |
| 10515 | R6 | 10.5 | -1.52 | -0.14 | 6 | 1 |
| 10515 | R7 | 9.19 | -0.85 | -0.09 | 6 | 1 |
| 10515 | R8 | 8.48 | 1.33 | 0.16 | 3 | 2 |
| 10517 | L2 | 8.83 | 5.06 | 0.57 | 4 | 4 |
| 10517 | L3 | 7.39 | 6.49 | 0.88 | 4 | 4 |
| 10517 | L4 | 7.17 | 8.58 | 1.2 | 4 | 5 |
| 10517 | L5 | 9.27 | 7.97 | 0.86 | 4 | 4 |
| 10517 | R4 | 10.24 | 6.37 | 0.62 | 4 | 4 |
| 10517 | R5 | 10.17 | 6.29 | 0.62 | 4 | 4 |
| 10517 | R6 | 10.3 | 8.16 | 0.79 | 4 | 4 |
| 10517 | R7 | 7.85 | 6.25 | 0.8 | 4 | 4 |
| 10549 | L3 | 10.23 | -1.72 | -0.17 | 6 | 1 |
| 10549 | L4 | 11.25 | -0.27 | -0.02 | 6 | 1 |
| 10549 | L5 | 10.66 | 0.75 | 0.07 | 2 | 2 |
| 10549 | L6 | 7.87 | 0.43 | 0.05 | 2 | 1 |
| 10549 | R5 | 10.78 | 1 | 0.09 | 1 | 2 |
| 10549 | R6 | 11.52 | 0.87 | 0.08 | 1 | 2 |
| 10549 | R7 | 10.88 | -0.26 | -0.02 | 1 | 1 |
| 10549 | R8 | 10.5 | -0.59 | -0.06 | 1 | 1 |
| 10553 | L2 | 8.86 | -1.21 | -0.14 | 6 | 1 |
| 10553 | L3 | 9.4 | -0.65 | -0.07 | 6 | 1 |
| 10553 | L4 | 10.06 | 1.43 | 0.14 | 6 | 2 |
| 10553 | L5 | 9.38 | 0.07 | 0.01 | 6 | 1 |
| 10553 | R4 | 10.36 | -0.27 | -0.03 | 1 | 1 |
| 10553 | R5 | 9.61 | -1.43 | -0.15 | 1 | 1 |
| 10553 | R6 | 10.06 | -0.98 | -0.1 | 1 | 1 |
| 10553 | R7 | 7.2 | -0.16 | -0.02 | 1 | 1 |
| 10554 | L3 | 7.83 | 0.89 | 0.11 | 2 | 2 |
| 10554 | L4 | 9.56 | -0.06 | -0.01 | 6 | 1 |
| 10554 | L5 | 11 | -0.41 | -0.04 | 6 | 1 |
| 10554 | L6 | 10.14 | -0.23 | -0.02 | 6 | 1 |
| 10554 | R1 | 10.29 | -0.34 | -0.03 | 1 | 1 |
| 10554 | R2 | 10.26 | -0.3 | -0.03 | 6 | 1 |
| 10554 | R3 | 9.48 | -0.54 | -0.06 | 1 | 1 |
| 10554 | R4 | 9.47 | -0.52 | -0.06 | 6 | 1 |
| 10554 | R5 | 9.53 | -0.14 | -0.01 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10554 | R6 | 9.47 | -0.07 | -0.01 | 6 | 1 |
| 10554 | R7 | 8.88 | 0.64 | 0.07 | 1 | 2 |
| 10554 | R8 | 8.83 | 0.65 | 0.07 | 6 | 2 |
| 10555 | L3 | 8.19 | 0.61 | 0.07 | 6 | 2 |
| 10555 | L4 | 5.54 | -0.26 | -0.05 | 6 | 1 |
| 10555 | L5 | 5 | 0.07 | 0.01 | 6 | 1 |
| 10555 | R5 | 6.42 | 0.36 | 0.06 | 6 | 1 |
| 10555 | R6 | 6.8 | 1.85 | 0.27 | 6 | 3 |
| 10569 | L2 | 9.11 | 1.39 | 0.15 | 2 | 2 |
| 10569 | L3 | 9.14 | 1.46 | 0.16 | 3 | 2 |
| 10569 | L4 | 10.79 | 0.7 | 0.07 | 2 | 2 |
| 10569 | L5 | 9.29 | 1.68 | 0.18 | 2 | 2 |
| 10569 | L6 | 12.42 | -0.48 | -0.04 | 6 | 1 |
| 10569 | R4 | 8.51 | -0.44 | -0.05 | 6 | 1 |
| 10569 | R5 | 7.61 | 1.76 | 0.23 | 3 | 3 |
| 10569 | R6 | 8.73 | 1.69 | 0.19 | 3 | 2 |
| 10569 | R7 | 8.09 | 1.98 | 0.24 | 3 | 3 |
| 10570 | L2 | 10.88 | -0.59 | -0.05 | 1 | 1 |
| 10570 | L3 | 10.69 | -0.55 | -0.05 | 1 | 1 |
| 10570 | L4 | 12.01 | 0.11 | 0.01 | 1 | 1 |
| 10570 | L5 | 11.14 | -0.4 | -0.04 | 1 | 1 |
| 10570 | R4 | 11.27 | -0.52 | -0.05 | 1 | 1 |
| 10570 | R5 | 11.28 | -0.72 | -0.06 | 1 | 1 |
| 10570 | R6 | 11.52 | 0.48 | 0.04 | 1 | 1 |
| 10570 | R7 | 10.74 | -0.93 | -0.09 | 1 | 1 |
| 10571 | L3 | 11.97 | 1.69 | 0.14 | 6 | 2 |
| 10571 | L4 | 11.03 | 1.08 | 0.1 | 6 | 2 |
| 10571 | L5 | 13.31 | 0.98 | 0.07 | 6 | 2 |
| 10571 | L6 | 9.89 | 3.07 | 0.31 | 3 | 3 |
| 10571 | R3 | 9.63 | 7.52 | 0.78 | 4 | 4 |
| 10571 | R4 | 10.27 | 5.13 | 0.5 | 3 | 4 |
| 10571 | R5 | 10.22 | 5.11 | 0.5 | 4 | 4 |
| 10571 | R6 | 9.45 | 2.08 | 0.22 | 6 | 3 |
| 10571 | R7 | 12.64 | 1.16 | 0.09 | 2 | 2 |
| 10572 | L2 | 8.62 | -0.01 | 0 | 6 | 1 |
| 10572 | L3 | 8.11 | -0.94 | -0.12 | 6 | 1 |
| 10572 | L4 | 9.39 | -1.07 | -0.11 | 6 | 1 |
| 10572 | L5 | 9.56 | 1.57 | 0.16 | 2 | 2 |
| 10572 | R3 | 8.15 | 1.52 | 0.19 | 6 | 2 |
| 10572 | R4 | 10.06 | -1.87 | -0.19 | 6 | 1 |
| 10572 | R5 | 9.72 | -1.27 | -0.13 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10572 | R6 | 9.69 | -1.27 | -0.13 | 6 | 1 |
| 10572 | R7 | 8.04 | -0.25 | -0.03 | 1 | 1 |
| 10572 | R8 | 8.09 | -0.25 | -0.03 | 6 | 1 |
| 10573 | L3 | 9.05 | 0.24 | 0.03 | 1 | 1 |
| 10573 | L4 | 9.01 | -0.47 | -0.05 | 1 | 1 |
| 10573 | L5 | 9.96 | 0.27 | 0.03 | 1 | 1 |
| 10573 | L6 | 7.74 | -0.57 | -0.07 | 1 | 1 |
| 10573 | R4 | 10.41 | 0.26 | 0.02 | 2 | 1 |
| 10573 | R5 | 10.87 | -0.87 | -0.08 | 6 | 1 |
| 10573 | R6 | 10.07 | -0.65 | -0.06 | 6 | 1 |
| 10573 | R7 | 7.67 | -0.84 | -0.11 | 6 | 1 |
| 10574 | L3 | 9.82 | -0.32 | -0.03 | 6 | 1 |
| 10574 | L4 | 9.37 | -0.56 | -0.06 | 6 | 1 |
| 10574 | L5 | 10.07 | -0.56 | -0.06 | 6 | 1 |
| 10574 | L6 | 8.57 | 0.78 | 0.09 | 2 | 2 |
| 10574 | R4 | 10.08 | 2.3 | 0.23 | 2 | 3 |
| 10574 | R5 | 11.62 | -1.28 | -0.11 | 6 | 1 |
| 10574 | R6 | 11.11 | -1 | -0.09 | 6 | 1 |
| 10574 | R7 | 11.2 | -0.77 | -0.07 | 6 | 1 |
| 10575 | L2 | 9.82 | -0.1 | -0.01 | 1 | 1 |
| 10575 | L3 | 9.26 | -1.78 | -0.19 | 1 | 1 |
| 10575 | L4 | 9.93 | 0.79 | 0.08 | 1 | 2 |
| 10575 | L5 | 9.72 | 0.03 | 0 | 1 | 1 |
| 10575 | R3 | 7.2 | -0.22 | -0.03 | 1 | 1 |
| 10575 | R3 | 7.16 | -0.25 | -0.03 | 6 | 1 |
| 10575 | R4 | 9.54 | 0.31 | 0.03 | 1 | 1 |
| 10575 | R4 | 9.47 | 0.32 | 0.03 | 6 | 1 |
| 10575 | R5 | 10.23 | 0.9 | 0.09 | 1 | 2 |
| 10575 | R5 | 10.17 | 0.9 | 0.09 | 6 | 2 |
| 10575 | R6 | 8.69 | -0.44 | -0.05 | 1 | 1 |
| 10575 | R6 | 8.57 | -0.48 | -0.06 | 6 | 1 |
| 10576 | L2 | 9.52 | -0.74 | -0.08 | 1 | 1 |
| 10576 | L3 | 9.11 | 0.23 | 0.03 | 1 | 1 |
| 10576 | L4 | 9.12 | 1.01 | 0.11 | 1 | 2 |
| 10576 | L5 | 9.12 | 0.87 | 0.1 | 1 | 2 |
| 10576 | R3 | 8.59 | 1.2 | 0.14 | 1 | 2 |
| 10576 | R4 | 8.72 | 0.21 | 0.02 | 1 | 1 |
| 10576 | R5 | 9.29 | 1 | 0.11 | 1 | 2 |
| 10576 | R6 | 9.36 | 1.28 | 0.14 | 1 | 2 |
| 10586 | L3 | 8.77 | 1.25 | 0.14 | 3 | 2 |
| 10586 | L4 | 9.79 | 2.83 | 0.29 | 3 | 3 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10586 | L5 | 12.87 | -0.47 | -0.04 | 6 | 1 |
| 10586 | L6 | 10.84 | -0.63 | -0.06 | 6 | 1 |
| 10586 | R3 | 9.47 | -0.17 | -0.02 | 1 | 1 |
| 10586 | R4 | 11.34 | 0.13 | 0.01 | 1 | 1 |
| 10586 | R5 | 9.29 | -0.53 | -0.06 | 1 | 1 |
| 10586 | R6 | 8.25 | 0.86 | 0.1 | 1 | 2 |
| 10589 | L3 | 4.41 | 6.98 | 1.58 | 5 | 5 |
| 10589 | L3 | 4.48 | 7.03 | 1.57 | 6 | 5 |
| 10589 | L4 | 6.92 | 7.74 | 1.12 | 5 | 5 |
| 10589 | L4 | 6.88 | 7.63 | 1.11 | 6 | 5 |
| 10589 | L5 | 7.06 | 8.15 | 1.15 | 5 | 5 |
| 10589 | L5 | 7.18 | 8.25 | 1.15 | 6 | 5 |
| 10589 | L6 | 4.52 | 6.87 | 1.52 | 5 | 5 |
| 10589 | L6 | 4.42 | 6.67 | 1.51 | 6 | 5 |
| 10589 | R3 | 3.79 | 8.28 | 2.18 | 6 | 5 |
| 10589 | R4 | 7.43 | 6.98 | 0.94 | 6 | 4 |
| 10589 | R5 | 9.57 | 0.39 | 0.04 | 6 | 1 |
| 10589 | R6 | 9.87 | -0.42 | -0.04 | 6 | 1 |
| 10595 | L3 | 9.17 | -0.13 | -0.01 | 1 | 1 |
| 10595 | L4 | 10.27 | 0.52 | 0.05 | 1 | 2 |
| 10595 | L5 | 9.51 | 0.8 | 0.08 | 1 | 2 |
| 10595 | L6 | 8.83 | 0.73 | 0.08 | 1 | 2 |
| 10595 | R4 | 10.13 | 0.83 | 0.08 | 1 | 2 |
| 10595 | R5 | 11.22 | 0.58 | 0.05 | 1 | 2 |
| 10595 | R6 | 9.88 | -0.22 | -0.02 | 1 | 1 |
| 10595 | R7 | 9.43 | -0.71 | -0.08 | 1 | 1 |
| 10596 | L3 | 9.9 | 1.29 | 0.13 | 2 | 2 |
| 10596 | L4 | 10.35 | 0.77 | 0.07 | 2 | 2 |
| 10596 | L5 | 10.22 | 1.91 | 0.19 | 2 | 2 |
| 10596 | L6 | 7.74 | 3.27 | 0.42 | 3 | 3 |
| 10596 | R3 | 9.04 | 4.78 | 0.53 | 4 | 4 |
| 10596 | R4 | 8.81 | 5.18 | 0.59 | 4 | 4 |
| 10596 | R5 | 7.22 | 4.16 | 0.58 | 4 | 4 |
| 10596 | R6 | 7.34 | 4.15 | 0.57 | 4 | 4 |
| 10626 | L3 | 9.96 | -1.18 | -0.12 | 1 | 1 |
| 10626 | L4 | 10.61 | -0.11 | -0.01 | 1 | 1 |
| 10626 | L5 | 10.47 | -1.26 | -0.12 | 1 | 1 |
| 10626 | L6 | 9.92 | -0.95 | -0.1 | 1 | 1 |
| 10626 | R3 | 9.27 | -0.36 | -0.04 | 6 | 1 |
| 10626 | R4 | 10.5 | -1.22 | -0.12 | 6 | 1 |
| 10626 | R5 | 12.07 | -0.61 | -0.05 | 6 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10626 | R6 | 11.28 | -0.6 | -0.05 | 6 | 1 |
| 10627 | L3 | 9.58 | -1.1 | -0.11 | 6 | 1 |
| 10627 | L4 | 12.78 | -0.71 | -0.06 | 6 | 1 |
| 10627 | L5 | 12.89 | 0.66 | 0.05 | 2 | 2 |
| 10627 | R3 | 10.59 | -0.63 | -0.06 | 1 | 1 |
| 10627 | R4 | 12.13 | -0.15 | -0.01 | 1 | 1 |
| 10627 | R5 | 11.63 | -0.56 | -0.05 | 1 | 1 |
| 10627 | R6 | 10.81 | -0.46 | -0.04 | 1 | 1 |
| 10629 | L3 | 8.37 | 0.96 | 0.11 | 2 | 2 |
| 10629 | L4 | 10.6 | 0.88 | 0.08 | 2 | 2 |
| 10629 | L5 | 11.68 | 1.05 | 0.09 | 2 | 2 |
| 10629 | L6 | 11.51 | -0.45 | -0.04 | 6 | 1 |
| 10629 | R2 | 8.32 | 1.2 | 0.14 | 2 | 2 |
| 10629 | R3 | 8.91 | 1.04 | 0.12 | 2 | 2 |
| 10629 | R4 | 7.27 | 0.67 | 0.09 | 2 | 2 |
| 10629 | R5 | 9.55 | 2.18 | 0.23 | 2 | 3 |
| 10629 | R6 | 9.45 | 2.12 | 0.22 | 3 | 3 |
| 10631 | L3 | 8.27 | 0.35 | 0.04 | 6 | 1 |
| 10631 | L4 | 11.94 | -0.1 | -0.01 | 6 | 1 |
| 10631 | L5 | 10.28 | 1.46 | 0.14 | 2 | 2 |
| 10631 | L6 | 8.26 | 1.65 | 0.2 | 2 | 3 |
| 10631 | R3 | 9.39 | 0.48 | 0.05 | 6 | 1 |
| 10631 | R4 | 9.8 | -0.27 | -0.03 | 6 | 1 |
| 10631 | R5 | 8.91 | 0.25 | 0.03 | 6 | 1 |
| 10631 | R6 | 7.76 | -0.36 | -0.05 | 6 | 1 |
| 10638 | L1 | 7.13 | 1.37 | 0.19 | 2 | 3 |
| 10638 | L2 | 7.08 | 1.45 | 0.2 | 6 | 3 |
| 10638 | L3 | 11.58 | -0.53 | -0.05 | 6 | 1 |
| 10638 | L4 | 11.55 | -0.27 | -0.02 | 2 | 1 |
| 10638 | L5 | 11.52 | -0.23 | -0.02 | 6 | 1 |
| 10638 | L6 | 11.72 | 0.46 | 0.04 | 2 | 1 |
| 10638 | L7 | 11.64 | 0.35 | 0.03 | 6 | 1 |
| 10638 | R4 | 5.61 | -1.06 | -0.19 | 6 | 1 |
| 10638 | R5 | 9.84 | 2.56 | 0.26 | 3 | 3 |
| 10638 | R6 | 9.5 | 1.97 | 0.21 | 3 | 3 |
| 10638 | R7 | 6.03 | 2.12 | 0.35 | 3 | 3 |
| 10638 | R8 | 6.8 | 3.59 | 0.53 | 3 | 4 |
| 10639 | L3 | 10.66 | 0.68 | 0.06 | 2 | 2 |
| 10639 | L4 | 10.02 | 0.72 | 0.07 | 2 | 2 |
| 10639 | L5 | 11.37 | -0.57 | -0.05 | 2 | 1 |
| 10639 | L6 | 11.37 | 0.97 | 0.08 | 2 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10639 | R3 | 11.49 | -1.88 | -0.16 | 1 | 1 |
| 10639 | R4 | 11.17 | -1.64 | -0.15 | 1 | 1 |
| 10639 | R5 | 10.6 | -0.42 | -0.04 | 1 | 1 |
| 10639 | R6 | 10.36 | -0.02 | 0 | 1 | 1 |
| 10640 | L3 | 11.11 | -2.21 | -0.2 | 6 | 1 |
| 10640 | L4 | 10.45 | -1.16 | -0.11 | 6 | 1 |
| 10640 | L5 | 8.7 | 0.68 | 0.08 | 2 | 2 |
| 10640 | L6 | 8.97 | 0.67 | 0.07 | 2 | 2 |
| 10640 | R3 | 10.16 | -0.32 | -0.03 | 6 | 1 |
| 10640 | R4 | 10.36 | 0.63 | 0.06 | 6 | 2 |
| 10640 | R5 | 11.45 | -0.22 | -0.02 | 6 | 1 |
| 10640 | R6 | 6.8 | 3.83 | 0.56 | 2 | 4 |
| 10642 | L3 | 6.01 | -0.08 | -0.01 | 6 | 1 |
| 10642 | L4 | 8.79 | 0.71 | 0.08 | 6 | 2 |
| 10642 | L5 | 10.99 | -0.27 | -0.03 | 6 | 1 |
| 10642 | L6 | 11.36 | 1.19 | 0.1 | 6 | 2 |
| 10642 | L7 | 12.45 | 0.61 | 0.05 | 6 | 2 |
| 10642 | R2 | 10.25 | -0.08 | -0.01 | 1 | 1 |
| 10642 | R2 | 10.23 | -0.19 | -0.02 | 6 | 1 |
| 10642 | R3 | 9.45 | -0.48 | -0.05 | 1 | 1 |
| 10642 | R3 | 9.48 | -0.44 | -0.05 | 6 | 1 |
| 10642 | R4 | 9.18 | -1.19 | -0.13 | 1 | 1 |
| 10642 | R4 | 9.18 | -1.06 | -0.12 | 6 | 1 |
| 10642 | R5 | 9.3 | 0.35 | 0.04 | 1 | 1 |
| 10642 | R5 | 9.3 | 0.27 | 0.03 | 6 | 1 |
| 10642 | R6 | 9.13 | -0.86 | -0.09 | 1 | 1 |
| 10643 | L3 | 11.5 | 0.31 | 0.03 | 1 | 1 |
| 10643 | L4 | 11.37 | -1.35 | -0.12 | 1 | 1 |
| 10643 | L5 | 11.03 | -1.74 | -0.16 | 1 | 1 |
| 10643 | L6 | 4.46 | 1.75 | 0.39 | 6 | 3 |
| 10643 | R3 | 7.15 | 1.22 | 0.17 | 6 | 3 |
| 10643 | R4 | 8.06 | 1.01 | 0.13 | 6 | 2 |
| 10643 | R5 | 11.18 | -1.45 | -0.13 | 6 | 1 |
| 10643 | R6 | 11.86 | 0.88 | 0.07 | 6 | 2 |
| 10645 | L2 | 10.52 | -2.3 | -0.22 | 1 | 1 |
| 10645 | L2 | 10.35 | -2.26 | -0.22 | 6 | 1 |
| 10645 | L3 | 10.94 | -0.77 | -0.07 | 1 | 1 |
| 10645 | L3 | 11.03 | -0.77 | -0.07 | 6 | 1 |
| 10645 | L4 | 10.66 | -0.13 | -0.01 | 1 | 1 |
| 10645 | L4 | 10.52 | -0.2 | -0.02 | 6 | 1 |
| 10645 | L5 | 10.04 | 0.72 | 0.07 | 2 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10645 | L5 | 10 | 0.74 | 0.07 | 6 | 2 |
| 10645 | L6 | 9.46 | 1.19 | 0.13 | 2 | 2 |
| 10645 | R2 | 7.58 | 4.6 | 0.61 | 3 | 4 |
| 10645 | R3 | 7.58 | 4.56 | 0.6 | 6 | 4 |
| 10645 | R4 | 9.78 | 0.57 | 0.06 | 1 | 2 |
| 10645 | R5 | 9.75 | 0.67 | 0.07 | 6 | 2 |
| 10645 | R6 | 10.3 | -0.34 | -0.03 | 1 | 1 |
| 10645 | R7 | 9.16 | 1.17 | 0.13 | 1 | 2 |
| 10646 | L3 | 9.68 | 1.29 | 0.13 | 6 | 2 |
| 10646 | L4 | 10.71 | 1.09 | 0.1 | 6 | 2 |
| 10646 | L5 | 10.76 | 0.98 | 0.09 | 6 | 2 |
| 10646 | L6 | 10.25 | 3.38 | 0.33 | 3 | 3 |
| 10646 | R4 | 8.17 | 4.68 | 0.57 | 3 | 4 |
| 10646 | R4 | 8.17 | 4.63 | 0.57 | 4 | 4 |
| 10646 | R5 | 7.25 | 3.63 | 0.5 | 3 | 4 |
| 10646 | R5 | 7.29 | 3.65 | 0.5 | 4 | 4 |
| 10646 | R6 | 7.94 | 4.27 | 0.54 | 3 | 4 |
| 10646 | R6 | 7.93 | 4.23 | 0.53 | 4 | 4 |
| 10646 | R7 | 6.29 | 3.15 | 0.5 | 3 | 4 |
| 10646 | R7 | 6.2 | 3.1 | 0.5 | 4 | 4 |
| 10647 | L4 | 11.84 | 0.87 | 0.07 | 2 | 2 |
| 10647 | L5 | 9.42 | 0.29 | 0.03 | 6 | 1 |
| 10647 | L6 | 8.55 | 2.67 | 0.31 | 3 | 3 |
| 10647 | L7 | 7.33 | 2.32 | 0.32 | 3 | 3 |
| 10647 | R4 | 10.37 | -0.6 | -0.06 | 1 | 1 |
| 10647 | R5 | 10.68 | -0.44 | -0.04 | 1 | 1 |
| 10647 | R6 | 11.68 | 0.57 | 0.05 | 1 | 2 |
| 10647 | R7 | 10.65 | -1.1 | -0.1 | 1 | 1 |
| 10666 | L3 | 6.48 | 2.78 | 0.43 | 3 | 3 |
| 10666 | L4 | 8.8 | 2.96 | 0.34 | 3 | 3 |
| 10666 | L5 | 12.06 | 4.19 | 0.35 | 3 | 3 |
| 10666 | L6 | 12.3 | 5.88 | 0.48 | 4 | 4 |
| 10666 | R4 | 11.29 | 6.63 | 0.59 | 4 | 4 |
| 10666 | R5 | 12 | 6.6 | 0.55 | 4 | 4 |
| 10666 | R6 | 11.45 | 4.57 | 0.4 | 4 | 3 |
| 10666 | R7 | 10.18 | 4.81 | 0.47 | 4 | 3 |
| 10667 | L2 | 9.8 | 2.05 | 0.21 | 6 | 2 |
| 10667 | L3 | 11.39 | 1.04 | 0.09 | 6 | 2 |
| 10667 | L4 | 10.79 | 0.65 | 0.06 | 1 | 2 |
| 10667 | L5 | 9.94 | -0.4 | -0.04 | 1 | 1 |
| 10667 | R3 | 8.55 | 0.32 | 0.04 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10667 | R4 | 9.26 | 0.41 | 0.04 | 1 | 1 |
| 10667 | R5 | 9.25 | -0.24 | -0.03 | 1 | 1 |
| 10667 | R6 | 8.21 | 0.09 | 0.01 | 1 | 1 |
| 10667 | R7 | 8.16 | 0.1 | 0.01 | 2 | 1 |
| 10670 | L2 | 9.49 | -0.06 | -0.01 | 6 | 1 |
| 10670 | L3 | 10.16 | 0.04 | 0 | 6 | 1 |
| 10670 | L4 | 12.43 | 0.39 | 0.03 | 2 | 1 |
| 10670 | L5 | 12.38 | 0.39 | 0.03 | 6 | 1 |
| 10670 | L6 | 12.8 | 1.16 | 0.09 | 2 | 2 |
| 10670 | L7 | 12.81 | 1.25 | 0.1 | 6 | 2 |
| 10670 | R3 | 9.23 | 2.77 | 0.3 | 6 | 3 |
| 10670 | R4 | 12.37 | 1.54 | 0.12 | 2 | 2 |
| 10670 | R5 | 12.2 | 1.08 | 0.09 | 2 | 2 |
| 10670 | R6 | 12.02 | 1.25 | 0.1 | 2 | 2 |
| 10670 | R7 | 11.6 | -0.65 | -0.06 | 6 | 1 |
| 10671 | L3 | 9.25 | -1.81 | -0.2 | 1 | 1 |
| 10671 | L4 | 11.01 | -0.01 | 0 | 1 | 1 |
| 10671 | L5 | 10.78 | 0.21 | 0.02 | 1 | 1 |
| 10671 | L6 | 10.85 | 1.39 | 0.13 | 1 | 2 |
| 10671 | R3 | 7.48 | 1.29 | 0.17 | 2 | 2 |
| 10671 | R4 | 10.27 | 1.15 | 0.11 | 2 | 2 |
| 10671 | R5 | 8.76 | -1.23 | -0.14 | 6 | 1 |
| 10671 | R6 | 10.38 | -1.49 | -0.14 | 6 | 1 |
| 10713 | L2 | 10.24 | 0.81 | 0.08 | 1 | 2 |
| 10713 | L3 | 11.9 | 0.81 | 0.07 | 1 | 2 |
| 10713 | L4 | 11.9 | 0.75 | 0.06 | 1 | 2 |
| 10713 | L5 | 9.63 | -0.51 | -0.05 | 1 | 1 |
| 10713 | R2 | 9.76 | 0.63 | 0.06 | 2 | 2 |
| 10713 | R3 | 9.79 | 0.61 | 0.06 | 6 | 2 |
| 10713 | R4 | 10.76 | -0.07 | -0.01 | 6 | 1 |
| 10713 | R5 | 11.83 | -0.11 | -0.01 | 6 | 1 |
| 10713 | R6 | 11.83 | 0.44 | 0.04 | 6 | 1 |
| 10714 | L3 | 3.95 | 4.96 | 1.25 | 4 | 5 |
| 10714 | L4 | 3.23 | 4.6 | 1.42 | 4 | 5 |
| 10714 | L5 | 2.89 | 5.27 | 1.82 | 4 | 5 |
| 10714 | R4 | 2.66 | 2.73 | 1.03 | 4 | 4 |
| 10714 | R5 | 6.25 | 5.38 | 0.86 | 4 | 4 |
| 10714 | R6 | 2.6 | 3.34 | 1.28 | 4 | 5 |
| 10714 | R7 | 3.2 | 4.9 | 1.53 | 4 | 5 |
| 10716 | L3 | 10.55 | 1 | 0.09 | 1 | 2 |
| 10716 | L4 | 10.31 | 1.28 | 0.12 | 1 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10716 | L5 | 10.19 | -0.26 | -0.03 | 1 | 1 |
| 10716 | L6 | 10.63 | 0.71 | 0.07 | 1 | 2 |
| 10716 | R4 | 8.64 | -0.49 | -0.06 | 6 | 1 |
| 10716 | R5 | 11.68 | 0.24 | 0.02 | 2 | 1 |
| 10716 | R6 | 10.44 | 0.02 | 0 | 6 | 1 |
| 10716 | R7 | 11.27 | -0.3 | -0.03 | 6 | 1 |
| 10720 | L3 | 9.34 | -0.09 | -0.01 | 1 | 1 |
| 10720 | L4 | 9.06 | 0.13 | 0.01 | 1 | 1 |
| 10720 | L5 | 9.44 | 0.15 | 0.02 | 1 | 1 |
| 10720 | L6 | 9.44 | -0.77 | -0.08 | 1 | 1 |
| 10720 | R3 | 8.77 | -0.47 | -0.05 | 6 | 1 |
| 10720 | R4 | 10.23 | -0.17 | -0.02 | 6 | 1 |
| 10720 | R5 | 10.65 | 1.12 | 0.1 | 2 | 2 |
| 10720 | R6 | 9.55 | 1.37 | 0.14 | 2 | 2 |
| 10732 | L2 | 6.12 | 3.06 | 0.5 | 3 | 4 |
| 10732 | L3 | 6.02 | 3.01 | 0.5 | 4 | 4 |
| 10732 | L4 | 6.99 | 2.12 | 0.3 | 3 | 3 |
| 10732 | L5 | 11.25 | 0.56 | 0.05 | 6 | 2 |
| 10732 | L6 | 9.47 | 2.94 | 0.31 | 6 | 3 |
| 10732 | R4 | 9.41 | 1.66 | 0.18 | 3 | 2 |
| 10732 | R5 | 7.38 | 3.69 | 0.5 | 3 | 4 |
| 10732 | R6 | 7.43 | 3.72 | 0.5 | 4 | 4 |
| 10732 | R7 | 5.16 | 5.85 | 1.13 | 4 | 5 |
| 10732 | R8 | 3.75 | 5.45 | 1.46 | 4 | 5 |
| 10733 | L3 | 10.06 | 0.2 | 0.02 | 1 | 1 |
| 10733 | L4 | 10.92 | -0.04 | 0 | 1 | 1 |
| 10733 | L5 | 11.58 | 0.5 | 0.04 | 1 | 1 |
| 10733 | L6 | 9.77 | 0.82 | 0.08 | 1 | 2 |
| 10733 | R4 | 10.35 | 0.03 | 0 | 6 | 1 |
| 10733 | R5 | 10.98 | -0.54 | -0.05 | 6 | 1 |
| 10733 | R6 | 10.58 | -0.63 | -0.06 | 6 | 1 |
| 10733 | R7 | 10.71 | 1.38 | 0.13 | 2 | 2 |
| 10734 | L2 | 10.69 | -0.9 | -0.08 | 1 | 1 |
| 10734 | L3 | 9.5 | 0.78 | 0.08 | 1 | 2 |
| 10734 | L4 | 11.04 | 2.13 | 0.19 | 6 | 2 |
| 10734 | R3 | 8.98 | 1.27 | 0.14 | 2 | 2 |
| 10734 | R4 | 10.64 | 0.24 | 0.02 | 2 | 1 |
| 10734 | R5 | 10.68 | -0.09 | -0.01 | 6 | 1 |
| 10734 | R6 | 11.53 | -0.09 | -0.01 | 6 | 1 |
| 10736 | L3 | 9.33 | -0.49 | -0.05 | 1 | 1 |
| 10736 | L4 | 10.22 | 1.21 | 0.12 | 1 | 2 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10736 | L5 | 9.48 | 0.19 | 0.02 | 1 | 1 |
| 10736 | L6 | 11 | 1.45 | 0.13 | 1 | 2 |
| 10736 | R3 | 9.65 | 6.19 | 0.64 | 6 | 4 |
| 10736 | R4 | 11.15 | 3.09 | 0.28 | 6 | 3 |
| 10736 | R5 | 12.42 | 1.29 | 0.1 | 6 | 2 |
| 10736 | R6 | 9.7 | 1.54 | 0.16 | 6 | 2 |
| 10737 | L3 | 11.33 | 1.36 | 0.12 | 2 | 2 |
| 10737 | L4 | 9.45 | -0.22 | -0.02 | 6 | 1 |
| 10737 | L5 | 10.53 | 0.92 | 0.09 | 2 | 2 |
| 10737 | L6 | 9.81 | 0.77 | 0.08 | 2 | 2 |
| 10737 | R3 | 9.86 | 0.67 | 0.07 | 1 | 2 |
| 10737 | R4 | 10.4 | 0.81 | 0.08 | 1 | 2 |
| 10737 | R5 | 8.34 | -0.63 | -0.08 | 1 | 1 |
| 10737 | R6 | 8.89 | 0.81 | 0.09 | 1 | 2 |
| 10740 | L3 | 9.21 | 0.47 | 0.05 | 2 | 1 |
| 10740 | L4 | 11.66 | 0.68 | 0.06 | 2 | 2 |
| 10740 | L5 | 12.69 | 0.79 | 0.06 | 2 | 2 |
| 10740 | L6 | 12.88 | 0.47 | 0.04 | 2 | 1 |
| 10740 | R3 | 11.53 | 0.38 | 0.03 | 1 | 1 |
| 10740 | R4 | 12.6 | -0.29 | -0.02 | 1 | 1 |
| 10740 | R5 | 11.95 | 0.04 | 0 | 1 | 1 |
| 10740 | R6 | 9.7 | -0.39 | -0.04 | 1 | 1 |
| 10741 | L3 | 7.6 | 0.47 | 0.06 | 1 | 1 |
| 10741 | L4 | 9.68 | -0.01 | 0 | 1 | 1 |
| 10741 | L5 | 10.05 | 1.47 | 0.15 | 2 | 2 |
| 10741 | L6 | 8.37 | 1.73 | 0.21 | 2 | 3 |
| 10741 | R3 | 7.04 | -0.19 | -0.03 | 6 | 1 |
| 10741 | R4 | 10.93 | 5.46 | 0.5 | 3 | 4 |
| 10741 | R5 | 11.62 | 6.41 | 0.55 | 3 | 4 |
| 10741 | R6 | 11.02 | 1.68 | 0.15 | 2 | 2 |
| 10788 | L2 | 6.8 | 0.95 | 0.14 | 1 | 2 |
| 10788 | L3 | 9.51 | -0.94 | -0.1 | 1 | 1 |
| 10788 | L4 | 10.34 | 0.84 | 0.08 | 1 | 2 |
| 10788 | L5 | 8.72 | 3.61 | 0.41 | 3 | 3 |
| 10788 | R5 | 5.39 | 5.71 | 1.06 | 4 | 5 |
| 10788 | R6 | 8.31 | 3.58 | 0.43 | 4 | 3 |
| 10788 | R7 | 8.06 | 4.26 | 0.53 | 4 | 4 |
| 10788 | R8 | 8.55 | 5.09 | 0.59 | 4 | 4 |
| 10791 | L3 | 10.86 | 0.22 | 0.02 | 2 | 1 |
| 10791 | L4 | 11.11 | -0.53 | -0.05 | 6 | 1 |
| 10791 | L5 | 9.25 | -0.69 | -0.07 | 6 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10791 | L6 | 9.02 | 1.25 | 0.14 | 2 | 2 |
| 10791 | R3 | 11.1 | -1.48 | -0.13 | 6 | 1 |
| 10791 | R4 | 11.29 | 1.53 | 0.14 | 2 | 2 |
| 10791 | R5 | 13.93 | 0.51 | 0.04 | 2 | 1 |
| 10791 | R6 | 10.69 | 0.47 | 0.04 | 2 | 1 |
| 10793 | L3 | 7.95 | 0.26 | 0.03 | 2 | 1 |
| 10793 | L4 | 11.56 | 0.36 | 0.03 | 2 | 1 |
| 10793 | L5 | 11.47 | -0.82 | -0.07 | 6 | 1 |
| 10793 | L6 | 11.11 | 0.09 | 0.01 | 6 | 1 |
| 10793 | R2 | 10.83 | 1.65 | 0.15 | 2 | 2 |
| 10793 | R3 | 10.66 | 2.39 | 0.22 | 2 | 3 |
| 10793 | R4 | 10.63 | 2.41 | 0.23 | 3 | 3 |
| 10793 | R5 | 10.2 | 0.19 | 0.02 | 2 | 1 |
| 10793 | R6 | 11.26 | 0.29 | 0.03 | 2 | 1 |
| 10793 | R7 | 9.1 | 0.67 | 0.07 | 2 | 2 |
| 10793 | R8 | 6.38 | 2.57 | 0.4 | 6 | 3 |
| 10794 | L2 | 6.3 | 1.68 | 0.27 | 6 | 3 |
| 10794 | L3 | 10.46 | 1.14 | 0.11 | 2 | 2 |
| 10794 | L4 | 11.15 | 0.65 | 0.06 | 2 | 2 |
| 10794 | L5 | 11.51 | -1.3 | -0.11 | 6 | 1 |
| 10794 | R3 | 10.72 | -0.3 | -0.03 | 6 | 1 |
| 10794 | R4 | 11.08 | -0.06 | -0.01 | 6 | 1 |
| 10794 | R5 | 10.56 | -1.74 | -0.16 | 6 | 1 |
| 10794 | R6 | 9.91 | 0.04 | 0 | 6 | 1 |
| 10833 | L3 | 7.92 | 4.35 | 0.55 | 4 | 4 |
| 10833 | L4 | 8.45 | 4.53 | 0.54 | 4 | 4 |
| 10833 | L5 | 8.6 | 5.3 | 0.62 | 4 | 4 |
| 10833 | L6 | 7.83 | 5.31 | 0.68 | 4 | 4 |
| 10833 | R3 | 4.59 | 5.06 | 1.1 | 5 | 5 |
| 10833 | R4 | 5.74 | 5.27 | 0.92 | 5 | 4 |
| 10833 | R5 | 6.09 | 6.06 | 0.99 | 5 | 4 |
| 10833 | R6 | 5.79 | 6.95 | 1.2 | 5 | 5 |
| 10837 | L1 | 9.23 | 2.69 | 0.29 | 3 | 3 |
| 10837 | L2 | 8.78 | 2.74 | 0.31 | 3 | 3 |
| 10837 | L3 | 8.92 | 4.86 | 0.54 | 3 | 4 |
| 10837 | L4 | 8.89 | 4.89 | 0.55 | 4 | 4 |
| 10837 | L5 | 8.51 | 4.81 | 0.56 | 3 | 4 |
| 10837 | L6 | 8.47 | 4.84 | 0.57 | 4 | 4 |
| 10837 | R4 | 7.33 | 3.24 | 0.44 | 6 | 3 |
| 10837 | R5 | 10.27 | 3.2 | 0.31 | 6 | 3 |
| 10837 | R6 | 7.26 | 4.03 | 0.56 | 4 | 4 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10837 | R7 | 8.57 | 2.91 | 0.34 | 6 | 3 |
| 10839 | L3 | 9.07 | -0.48 | -0.05 | 1 | 1 |
| 10839 | L4 | 9.85 | 0.16 | 0.02 | 1 | 1 |
| 10839 | L5 | 11.06 | -0.08 | -0.01 | 1 | 1 |
| 10839 | L6 | 10.46 | 2.33 | 0.22 | 6 | 3 |
| 10839 | R5 | 11.24 | 1.13 | 0.1 | 2 | 2 |
| 10839 | R6 | 11.85 | 0.64 | 0.05 | 2 | 2 |
| 10839 | R7 | 10.22 | -0.5 | -0.05 | 6 | 1 |
| 10839 | R8 | 7.79 | 0.51 | 0.06 | 6 | 2 |
| 10840 | L3 | 3.22 | 1.12 | 0.35 | 6 | 3 |
| 10840 | L4 | 7.35 | 0.39 | 0.05 | 1 | 1 |
| 10840 | L5 | 6.3 | 0.75 | 0.12 | 1 | 2 |
| 10840 | L6 | 6.93 | 0.69 | 0.1 | 1 | 2 |
| 10840 | R4 | 4.34 | 0.93 | 0.21 | 6 | 3 |
| 10840 | R5 | 5.15 | 3.02 | 0.59 | 6 | 4 |
| 10840 | R6 | 4.37 | 3.31 | 0.76 | 6 | 4 |
| 10840 | R7 | 4.95 | 2.05 | 0.41 | 6 | 3 |
| 10877 | L3 | 9.16 | -0.35 | -0.04 | 1 | 1 |
| 10877 | L4 | 10.9 | 0.02 | 0 | 1 | 1 |
| 10877 | L5 | 11.12 | -0.12 | -0.01 | 1 | 1 |
| 10877 | L6 | 9.57 | 1.89 | 0.2 | 6 | 2 |
| 10877 | R4 | 9 | 1.07 | 0.12 | 1 | 2 |
| 10877 | R5 | 9.46 | 0.13 | 0.01 | 1 | 1 |
| 10877 | R6 | 10.13 | 0.51 | 0.05 | 1 | 2 |
| 10878 | L2 | 11.83 | 0.89 | 0.07 | 2 | 2 |
| 10878 | L3 | 12 | 2.43 | 0.2 | 2 | 2 |
| 10878 | L4 | 11.47 | 1.99 | 0.17 | 2 | 2 |
| 10878 | L5 | 10.44 | 4.23 | 0.41 | 3 | 3 |
| 10878 | R3 | 8.98 | 0.16 | 0.02 | 1 | 1 |
| 10878 | R4 | 10.58 | -1.33 | -0.13 | 1 | 1 |
| 10878 | R5 | 10.95 | -0.69 | -0.06 | 1 | 1 |
| 10878 | R6 | 9.28 | -0.84 | -0.09 | 1 | 1 |
| 10879 | L3 | 12.62 | 3.69 | 0.29 | 2 | 3 |
| 10879 | L4 | 11.87 | 0.52 | 0.04 | 2 | 1 |
| 10879 | L5 | 8.96 | 0.06 | 0.01 | 6 | 1 |
| 10879 | L6 | 11.3 | 1.93 | 0.17 | 2 | 2 |
| 10879 | R4 | 10.74 | 2.39 | 0.22 | 2 | 3 |
| 10879 | R5 | 11.66 | 1.25 | 0.11 | 2 | 2 |
| 10879 | R6 | 10.34 | 2.08 | 0.2 | 2 | 2 |
| 10879 | R7 | 10.94 | 0.97 | 0.09 | 2 | 2 |
| 10882 | L3 | 9.54 | 0.32 | 0.03 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10882 | L4 | 9.2 | 1.07 | 0.12 | 1 | 2 |
| 10882 | L5 | 9.26 | 1.58 | 0.17 | 1 | 2 |
| 10882 | L6 | 8.49 | 0.15 | 0.02 | 1 | 1 |
| 10882 | R3 | 9.11 | 3.52 | 0.39 | 6 | 3 |
| 10882 | R4 | 10.12 | -0.6 | -0.06 | 6 | 1 |
| 10882 | R5 | 10.45 | 0.73 | 0.07 | 6 | 2 |
| 10882 | R6 | 7.53 | 1.66 | 0.22 | 6 | 3 |
| 10919 | L3 | 9.7 | 1.2 | 0.12 | 2 | 2 |
| 10919 | L4 | 10.24 | 2.4 | 0.23 | 2 | 3 |
| 10919 | L5 | 10.12 | 2.47 | 0.24 | 2 | 3 |
| 10919 | L6 | 8.87 | 3.72 | 0.42 | 6 | 3 |
| 10919 | R3 | 7.76 | 3.37 | 0.43 | 6 | 3 |
| 10919 | R4 | 9.1 | 2.26 | 0.25 | 6 | 3 |
| 10919 | R5 | 10.61 | 1.81 | 0.17 | 6 | 2 |
| 10919 | R6 | 9.87 | 0.4 | 0.04 | 6 | 1 |
| 10959 | L2 | 10 | -0.04 | 0 | 6 | 1 |
| 10959 | L3 | 9.02 | -0.89 | -0.1 | 6 | 1 |
| 10959 | L4 | 9.74 | -1.08 | -0.11 | 6 | 1 |
| 10959 | L5 | 9.74 | -0.92 | -0.09 | 6 | 1 |
| 10959 | R4 | 8.42 | 2.43 | 0.29 | 3 | 3 |
| 10959 | R5 | 9.25 | 3.57 | 0.39 | 3 | 3 |
| 10959 | R6 | 8.61 | 2.46 | 0.29 | 3 | 3 |
| 10959 | R7 | 6.92 | 3.46 | 0.5 | 3 | 4 |
| 10959 | R8 | 6.79 | 3.4 | 0.5 | 4 | 4 |
| 10960 | L3 | 11.76 | -0.58 | -0.05 | 6 | 1 |
| 10960 | L4 | 12.46 | -1.74 | -0.14 | 6 | 1 |
| 10960 | L5 | 11.58 | -1.34 | -0.12 | 6 | 1 |
| 10960 | L6 | 10.14 | 0.2 | 0.02 | 6 | 1 |
| 10960 | R4 | 12.36 | -0.48 | -0.04 | 2 | 1 |
| 10960 | R5 | 12.37 | 0.31 | 0.02 | 2 | 1 |
| 10960 | R6 | 10.62 | -0.55 | -0.05 | 6 | 1 |
| 10960 | R7 | 9.43 | 0.06 | 0.01 | 6 | 1 |
| 10962 | L2 | 9.3 | 0.37 | 0.04 | 2 | 1 |
| 10962 | L3 | 9.76 | 1.43 | 0.15 | 2 | 2 |
| 10962 | L4 | 10.8 | 0.6 | 0.06 | 2 | 2 |
| 10962 | L5 | 10.32 | 1.06 | 0.1 | 2 | 2 |
| 10962 | R4 | 8.17 | 1.51 | 0.18 | 2 | 2 |
| 10962 | R5 | 11.33 | 0.88 | 0.08 | 2 | 2 |
| 10962 | R6 | 11.65 | 0.1 | 0.01 | 2 | 1 |
| 10962 | R7 | 10.02 | 0.39 | 0.04 | 2 | 1 |
| 10969 | L2 | 9.17 | -0.9 | -0.1 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 10969 | L3 | 10.72 | -0.73 | -0.07 | 1 | 1 |
| 10969 | L4 | 10.27 | -0.2 | -0.02 | 1 | 1 |
| 10969 | L5 | 11.02 | -1.15 | -0.1 | 1 | 1 |
| 10969 | R3 | 10.16 | -0.76 | -0.07 | 1 | 1 |
| 10969 | R4 | 11.21 | -1.65 | -0.15 | 1 | 1 |
| 10969 | R5 | 12.41 | -1.59 | -0.13 | 1 | 1 |
| 10969 | R6 | 10.61 | 0.05 | 0.01 | 1 | 1 |
| 10989 | L3 | 5.11 | 5.43 | 1.06 | 5 | 4 |
| 10989 | L3 | 5.05 | 5.31 | 1.05 | 6 | 4 |
| 10989 | L4 | 7.02 | 7.5 | 1.07 | 5 | 5 |
| 10989 | L4 | 6.94 | 7.38 | 1.06 | 6 | 5 |
| 10989 | L5 | 5.63 | 6.78 | 1.2 | 5 | 5 |
| 10989 | L5 | 5.58 | 6.74 | 1.21 | 6 | 5 |
| 10989 | L6 | 4.62 | 4.41 | 0.95 | 5 | 4 |
| 10989 | L6 | 4.61 | 4.52 | 0.98 | 6 | 4 |
| 10989 | R4 | 5.18 | 4.95 | 0.96 | 5 | 4 |
| 10989 | R5 | 3.8 | 8.47 | 2.23 | 5 | 5 |
| 10989 | R6 | 3.55 | 8.45 | 2.38 | 5 | 5 |
| 10989 | R7 | 3.12 | 6.54 | 2.1 | 5 | 5 |
| 10998 | L3 | 11.1 | -1.37 | -0.12 | 1 | 1 |
| 10998 | L4 | 10.41 | 0.72 | 0.07 | 1 | 2 |
| 10998 | L5 | 10.15 | 0.79 | 0.08 | 1 | 2 |
| 10998 | L6 | 9.66 | 0.54 | 0.06 | 1 | 2 |
| 10998 | R4 | 10.49 | 1.86 | 0.18 | 2 | 2 |
| 10998 | R5 | 10.4 | 1.68 | 0.16 | 2 | 2 |
| 10998 | R6 | 8.73 | 0.31 | 0.03 | 2 | 1 |
| 10998 | R7 | 9.07 | 2.73 | 0.3 | 2 | 3 |
| 11004 | L3 | 10.17 | -1.8 | -0.18 | 6 | 1 |
| 11004 | L4 | 11.12 | -1.32 | -0.12 | 6 | 1 |
| 11004 | L5 | 10.66 | -0.33 | -0.03 | 6 | 1 |
| 11004 | L6 | 10.15 | 1.26 | 0.12 | 2 | 2 |
| 11004 | R3 | 10.25 | 1.13 | 0.11 | 6 | 2 |
| 11004 | R4 | 10.74 | 0.18 | 0.02 | 2 | 1 |
| 11004 | R5 | 10.74 | -0.13 | -0.01 | 2 | 1 |
| 11004 | R6 | 8.58 | 2.2 | 0.26 | 6 | 3 |
| 11048 | L3 | 6.46 | 4.3 | 0.67 | 4 | 4 |
| 11048 | L4 | 7.91 | 5.15 | 0.65 | 4 | 4 |
| 11048 | L5 | 6.81 | 9.13 | 1.34 | 4 | 5 |
| 11048 | L6 | 8.33 | 7.41 | 0.89 | 4 | 4 |
| 11048 | R2 | 10.17 | 5.09 | 0.5 | 4 | 4 |
| 11048 | R3 | 8.26 | 5.32 | 0.64 | 4 | 4 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 11048 | R4 | 3.21 | 6.39 | 1.99 | 4 | 5 |
| 11048 | R5 | 5.03 | 3.89 | 0.77 | 4 | 4 |
| 11075 | L2 | 6.22 | 6.85 | 1.1 | 5 | 5 |
| 11075 | L3 | 5.37 | 8.14 | 1.51 | 5 | 5 |
| 11075 | L4 | 6.87 | 8.39 | 1.22 | 5 | 5 |
| 11075 | L5 | 5.58 | 8.75 | 1.57 | 5 | 5 |
| 11075 | R3 | 10.53 | 0.22 | 0.02 | 6 | 1 |
| 11075 | R4 | 11.13 | 0.25 | 0.02 | 6 | 1 |
| 11075 | R5 | 13.05 | -0.04 | 0 | 6 | 1 |
| 11075 | R6 | 10.22 | -0.44 | -0.04 | 6 | 1 |
| 11077 | L3 | 6.26 | 6.36 | 1.02 | 5 | 4 |
| 11077 | L4 | 6.25 | 6.51 | 1.04 | 5 | 5 |
| 11077 | L5 | 4.07 | 7.97 | 1.96 | 5 | 5 |
| 11077 | L6 | 6.28 | 8.56 | 1.36 | 5 | 5 |
| 11077 | R4 | 9.65 | 2.42 | 0.25 | 2 | 3 |
| 11077 | R5 | 11.71 | -0.19 | -0.02 | 6 | 1 |
| 11077 | R6 | 10.45 | -0.83 | -0.08 | 6 | 1 |
| 11077 | R7 | 8.79 | -0.73 | -0.08 | 6 | 1 |
| 11077 | R8 | 9.55 | -1.2 | -0.13 | 6 | 1 |
| 11080 | L3 | 9.97 | -0.5 | -0.05 | 6 | 1 |
| 11080 | L4 | 9.49 | -0.06 | -0.01 | 6 | 1 |
| 11080 | L5 | 7.74 | -0.54 | -0.07 | 6 | 1 |
| 11080 | L6 | 6.08 | 0.74 | 0.12 | 2 | 2 |
| 11080 | R4 | 8.34 | 0.79 | 0.09 | 2 | 2 |
| 11080 | R5 | 10.4 | 0.95 | 0.09 | 2 | 2 |
| 11080 | R6 | 10 | 0.72 | 0.07 | 2 | 2 |
| 11080 | R7 | 7.74 | 1.1 | 0.14 | 2 | 2 |
| 11108 | L2 | 2.62 | 4.64 | 1.77 | 5 | 5 |
| 11108 | L4 | 3.46 | 3.37 | 0.97 | 5 | 4 |
| 11108 | L5 | 6.53 | 1.98 | 0.3 | 6 | 3 |
| 11108 | R4 | 5.24 | 9.03 | 1.72 | 5 | 5 |
| 11108 | R5 | 4.57 | 6.6 | 1.44 | 5 | 5 |
| 11108 | R6 | 4.14 | 5.8 | 1.4 | 5 | 5 |
| 11108 | R7 | 1.54 | 4.63 | 3.01 | 5 | 5 |
| 11111 | L3 | 10.18 | -1.98 | -0.19 | 1 | 1 |
| 11111 | L4 | 10.6 | -1.5 | -0.14 | 1 | 1 |
| 11111 | L5 | 12.1 | -0.33 | -0.03 | 1 | 1 |
| 11111 | L6 | 12.11 | -0.83 | -0.07 | 1 | 1 |
| 11111 | R4 | 10.81 | 0.24 | 0.02 | 1 | 1 |
| 11111 | R5 | 11.23 | -0.39 | -0.03 | 1 | 1 |
| 11111 | R6 | 11.76 | -0.45 | -0.04 | 1 | 1 |

| Ref No | Slice | D_Len | D_Disp | Ratio | Sub Grp. | Discrim. |
|---|---|---|---|---|---|---|
| 11111 | R7 | 11.55 | -0.43 | -0.04 | 1 | 1 |
| 11146 | L2 | 9.03 | 3.3 | 0.36 | 6 | 3 |
| 11146 | L3 | 8.96 | 1.84 | 0.21 | 2 | 3 |
| 11146 | L4 | 10.74 | 2.54 | 0.24 | 2 | 3 |
| 11146 | L5 | 8.34 | 3.28 | 0.39 | 6 | 3 |
| 11146 | R3 | 9.03 | 6.04 | 0.67 | 4 | 4 |
| 11146 | R4 | 9.13 | 5.23 | 0.57 | 3 | 4 |
| 11146 | R5 | 9.09 | 5.23 | 0.57 | 4 | 4 |
| 11146 | R6 | 11.09 | 3.28 | 0.3 | 3 | 3 |
| 11146 | R7 | 8.95 | 1.62 | 0.18 | 3 | 2 |
| 11336 | L3 | 7.54 | 7.47 | 0.99 | 6 | 5 |
| 11336 | L4 | 5.64 | 7.59 | 1.35 | 6 | 5 |
| 11336 | L5 | 8.11 | 5.53 | 0.68 | 6 | 4 |
| 11336 | L6 | 4.46 | 4.93 | 1.11 | 6 | 5 |
| 11336 | R4 | 3.27 | 6.36 | 1.94 | 6 | 5 |
| 11336 | R5 | 5.62 | 7.74 | 1.38 | 6 | 5 |
| 11336 | R6 | 8.35 | 3.76 | 0.45 | 6 | 3 |
| 11336 | R7 | 6.49 | 4.15 | 0.64 | 6 | 4 |
| 11440 | L3 | 8.93 | 0.08 | 0.01 | 6 | 1 |
| 11440 | L4 | 9.94 | 1.06 | 0.11 | 6 | 2 |
| 11440 | L5 | 8.26 | 1.71 | 0.21 | 3 | 3 |
| 11440 | L6 | 7.6 | 4.16 | 0.55 | 3 | 4 |
| 11440 | L7 | 7.33 | 3.9 | 0.53 | 4 | 4 |
| 11440 | R3 | 9.55 | 5.3 | 0.55 | 4 | 4 |
| 11440 | R4 | 7 | 4.47 | 0.64 | 4 | 4 |
| 11440 | R5 | 8.73 | 2.7 | 0.31 | 3 | 3 |
| 11440 | R6 | 11.11 | 1.84 | 0.17 | 6 | 2 |

# Appendix 5(a)

## Angular Cephalometric Variables (Double Determination)

**Key:**

| | | |
|---|---|---|
| Ang a | initial determination in degrees | |
| Ang b | second determination in degrees | |
| Ang 1 | angular measurement | N-S-Ba |
| Ang 2 | angular measurement | SN/Ar-Go |
| Ang 3 | angular measurement | FH/Ar-Go |
| Ang 4 | angular measurement | FH/Co-Or |
| Ang 5 | angular measurement | BaN/Ptm-Gn |
| Ang 6 | angular measurement | UI-LI |
| Ang 7 | angular measurement | LI/Go-Me |
| Ang 8 | angular measurement | UI/ANS-PNS |
| Ang 9 | angular measurement | Ar-Go-Me |
| Ang 10 | angular measurement | SN/ANS-PNS |
| Ang 11 | angular measurement | SN/Go-Me |
| Ang 12 | angular measurement | FH/Go-Me |
| Ang 13 | angular measurement | ANS-PNS/Go-Me |

| Case ID | Ang a1 | Ang b1 | Ang a2 | Ang b2 | Ang a3 | Ang b3 | Ang a4 |
|---|---|---|---|---|---|---|---|
| 1782 | 130.8 | 130.514 | 85.339 | 84.069 | 74.407 | 73.662 | 3.757 |
| 2476 | 129.941 | 129.708 | 80.301 | 79.108 | 74.783 | 73.244 | -2.947 |
| 4005 | 132.043 | 132.957 | 79.246 | 78.965 | 70.636 | 69.372 | 5.075 |
| 4381 | 133.401 | 137.01 | 101.218 | 100.471 | 86.034 | 85 | 5.797 |
| 4703 | 130.933 | 131.207 | 84.888 | 85.18 | 75.726 | 76.043 | -1.782 |
| 5105 | 131.636 | 131.514 | 83.58 | 83.891 | 72.773 | 71.891 | 2.507 |
| 5748 | 124.015 | 120.112 | 102.802 | 102.72 | 96.894 | 96.795 | -1.019 |
| 6229 | 130.008 | 129.814 | 91.629 | 92.204 | 82.108 | 81.783 | 2.458 |
| 6429 | 126.338 | 125.39 | 95.162 | 94.114 | 89.039 | 87.721 | -1.363 |
| 6796 | 130.408 | 129.215 | 78.91 | 79.476 | 71.56 | 71.938 | 1.327 |
| 7702 | 124.073 | 124.973 | 91.999 | 90.299 | 83.195 | 80.591 | 2.686 |
| 7703 | 122.402 | 122.387 | 89.936 | 89.669 | 84.798 | 84.939 | 1.585 |
| 7747 | 135.786 | 135.27 | 87.291 | 85.679 | 74.61 | 72.139 | 0.827 |
| 7749 | 130.711 | 131.836 | 88.749 | 88.971 | 76.547 | 76.204 | 4.302 |
| 7767 | 126.07 | 128.454 | 81.795 | 81.816 | 74.889 | 73.515 | 1.004 |
| 7793 | 133.226 | 134.706 | 90.697 | 90.653 | 79.16 | 79.155 | 5.915 |
| 7856 | 130.123 | 130.258 | 85.791 | 83.781 | 74.682 | 73.667 | 1.41 |
| 7907 | 121.863 | 122.541 | 78.727 | 82.88 | 71.211 | 76.734 | 3.07 |
| 7939 | 128.957 | 129.11 | 80.484 | 80.044 | 69.841 | 70.156 | 3.539 |
| 7947 | 127.742 | 128.542 | 90.945 | 91.644 | 79.654 | 79.616 | 1.237 |

| Case ID | Ang a1 | Ang b1 | Ang a2 | Ang b2 | Ang a3 | Ang b3 | Ang a4 |
|---|---|---|---|---|---|---|---|
| 7963 | 125.054 | 125.468 | 80.349 | 78.41 | 73.23 | 71.173 | 1.31 |
| 7971 | 122.919 | 121.738 | 83.13 | 83.964 | 76.566 | 77.316 | 0.216 |
| 8014 | 131.651 | 132.851 | 89.557 | 88.5 | 78.51 | 77.136 | 4.381 |
| 8046 | 125.288 | 126.007 | 89.476 | 89.69 | 81.66 | 81.059 | 0.068 |
| 8063 | 129.403 | 129.256 | 83.106 | 83.695 | 78.291 | 79.307 | -1.134 |
| 8081 | 133.02 | 134.261 | 89.332 | 90.263 | 77.478 | 77.674 | -0.065 |
| 8089 | 124.984 | 126.959 | 86.309 | 83.186 | 78.108 | 74.6 | 0.299 |
| 8090 | 127.887 | 127.278 | 86.334 | 86.072 | 76.337 | 77.123 | 0.116 |
| 8121 | 125.427 | 126.228 | 81.177 | 81.295 | 73.809 | 72.736 | 1.463 |
| 8122 | 137.121 | 136.692 | 84.455 | 84.299 | 69.097 | 68.958 | 3.865 |
| 8163 | 127.355 | 128.547 | 86.884 | 87.925 | 77.984 | 78.168 | -0.602 |
| 8244 | 121.141 | 122.207 | 87.719 | 88.986 | 73.85 | 74.247 | 2.057 |
| 8254 | 115.953 | 117.768 | 84.718 | 86.674 | 79.495 | 81.355 | -1.198 |
| 8255 | 126.256 | 127.863 | 85.578 | 86.824 | 77.546 | 78.103 | -0.087 |
| 8258 | 124.653 | 125.293 | 92.834 | 92.618 | 83.098 | 82.95 | 1.358 |
| 8261 | 129.94 | 128.375 | 83.607 | 82.694 | 78.364 | 77.438 | 1.206 |
| 8288 | 128.798 | 129.063 | 90.449 | 89.755 | 80.948 | 80.022 | 0.45 |
| 8293 | 124.408 | 125.713 | 80.517 | 80.324 | 73.473 | 73.372 | 3.165 |
| 8294 | 124.38 | 121.614 | 88.486 | 88.59 | 80.905 | 81.471 | 0.579 |
| 9064 | 140.363 | 139.742 | 94.838 | 94.492 | 82.11 | 81.828 | 1.998 |
| 9087 | 126.763 | 126.876 | 87.13 | 86.535 | 79.025 | 77.951 | -3.652 |
| 9088 | 131.844 | 131.641 | 90.911 | 92.299 | 80.48 | 79.601 | 1.158 |
| 9092 | 124.659 | 125.916 | 89.853 | 91.189 | 79.95 | 80.097 | -3.195 |
| 9093 | 135.697 | 135.409 | 88.652 | 88.9 | 73.086 | 73.702 | 0.766 |
| 9124 | 132.553 | 131.802 | 88.815 | 88.75 | 79.184 | 79.513 | -3.521 |
| 9125 | 128.544 | 128.096 | 84.375 | 83.688 | 77.987 | 77.697 | 0.096 |
| 9128 | 122.724 | 123.449 | 89.807 | 89.71 | 82.649 | 82.594 | 2.131 |
| 9129 | 134.007 | 130.455 | 88.75 | 89.624 | 78.849 | 80.366 | 0.263 |
| 9161 | 121.368 | 118.087 | 79.332 | 78.034 | 73.725 | 72.064 | -1.126 |
| 9162 | 131.268 | 129.975 | 81.464 | 81.935 | 75.172 | 75.009 | 1.966 |
| 9163 | 138.012 | 137.265 | 89.525 | 87.768 | 80.292 | 79.359 | 0.454 |
| 9164 | 124.978 | 125.729 | 88.152 | 88.133 | 82.673 | 78.856 | 0.197 |
| 9202 | 131.871 | 128.872 | 87.516 | 87.132 | 75.807 | 75.487 | 0.767 |
| 9244 | 136.817 | 135.73 | 97.512 | 96.731 | 85.834 | 85.124 | 0.197 |
| 9247 | 129.272 | 127.02 | 82.586 | 83.514 | 73.739 | 74.345 | 1.155 |
| 9273 | 132.263 | 131.502 | 84.017 | 84.242 | 76.163 | 76.197 | 0.871 |
| 9274 | 125.174 | 124.042 | 92.487 | 93.279 | 78.453 | 79.926 | 5.315 |
| 9284 | 132.29 | 131.86 | 81.491 | 82.675 | 72.618 | 73.399 | -1.024 |
| 9309 | 131.19 | 131.35 | 90.257 | 90.857 | 80.874 | 80.789 | 2.821 |
| 9340 | 137.766 | 137.233 | 85.999 | 85.293 | 74.896 | 75.026 | 3.152 |
| 9344 | 124.579 | 123.094 | 80.73 | 80.481 | 72.499 | 72.037 | 1.429 |

| Case ID | Ang a1 | Ang b1 | Ang a2 | Ang b2 | Ang a3 | Ang b3 | Ang a4 |
|---|---|---|---|---|---|---|---|
| 9347 | 124.062 | 123.373 | 92.712 | 92.415 | 86.355 | 85.341 | -2.941 |
| 9382 | 136.356 | 137.821 | 85.302 | 85.169 | 71.149 | 71.15 | 4.633 |
| 9411 | 135.18 | 134.469 | 83.732 | 83.79 | 72.603 | 73.092 | 3.322 |
| 9467 | 137.136 | 136.614 | 78.69 | 78.547 | 69.022 | 69.31 | 2.134 |
| 9479 | 136.762 | 136.977 | 82.293 | 81.619 | 71.476 | 70.288 | 1.449 |
| 9559 | 128.933 | 125.632 | 78.238 | 77.938 | 73.253 | 72.587 | 3.547 |
| 9606 | 133.13 | 133.595 | 86.623 | 85.379 | 73.824 | 74.66 | 1.149 |
| 9650 | 134.408 | 134.24 | 95.664 | 95.271 | 85.093 | 85.192 | 2.879 |
| 9700 | 138.69 | 136.241 | 89.974 | 90.826 | 77.596 | 78.249 | 0.631 |
| 9702 | 125.279 | 125.684 | 90.208 | 89.817 | 80.921 | 79.263 | -0.165 |
| 9713 | 130.195 | 129.571 | 92.623 | 93.52 | 82.962 | 83.968 | 1.603 |
| 9733 | 119.076 | 118.022 | 84.195 | 84.217 | 84.327 | 84.666 | 0.912 |
| 9872 | 128.439 | 127.88 | 87.361 | 88.186 | 76.284 | 76.509 | 2.998 |
| 9873 | 127.7 | 128.803 | 84.771 | 86.241 | 73.922 | 74.924 | 3.51 |
| 9903 | 124.008 | 124.109 | 85.476 | 85.602 | 76.876 | 76.802 | 0.128 |
| 9910 | 128.8 | 129.267 | 89.562 | 90.099 | 79.893 | 80.359 | 3.226 |
| 9919 | 132.461 | 133.122 | 92.494 | 92.123 | 80.134 | 79.844 | 0.807 |
| 9938 | 121.444 | 123.574 | 92.455 | 91.86 | 86.328 | 86.171 | 1.678 |
| 9945 | 130.49 | 125.486 | 83.281 | 83.574 | 73.43 | 74.566 | 2.855 |
| 9984 | 132.041 | 132.406 | 96.154 | 95.301 | 82.017 | 81.775 | 1.343 |
| 9985 | 131.357 | 130.555 | 98.34 | 98.692 | 84.746 | 86.005 | -2.179 |
| 9988 | 131.981 | 129.019 | 85.78 | 84.227 | 76.683 | 75.489 | 2.497 |
| 10047 | 125.208 | 127.406 | 82.974 | 83.683 | 75.53 | 76.023 | 3.039 |
| 10048 | 132.205 | 132.066 | 81.67 | 81.216 | 72.193 | 72.02 | 2.258 |
| 10050 | 136.3 | 136.244 | 86.318 | 88.153 | 75.07 | 76.757 | 0.164 |
| 10071 | 124.887 | 124.941 | 88.638 | 87.096 | 78.986 | 78.33 | 0.85 |
| 10110 | 121.829 | 121.774 | 91.414 | 90.455 | 83.416 | 82.434 | -0.78 |
| 10112 | 132.429 | 131.561 | 82.633 | 81.725 | 73.292 | 72.984 | 0.529 |
| 10133 | 130.076 | 130.608 | 90.344 | 90.868 | 82.662 | 83.642 | -1.354 |
| 10140 | 135.665 | 134.305 | 96.284 | 94.554 | 84.41 | 83.174 | 0.328 |
| 10141 | 126.795 | 128.763 | 83.788 | 85.203 | 74.524 | 76.073 | 1.485 |
| 10174 | 128.369 | 128.973 | 75.203 | 76.657 | 65.1 | 66.296 | 2.813 |
| 10176 | 128.155 | 129.447 | 83.067 | 82.234 | 74.607 | 73.964 | 1.983 |
| 10233 | 138.38 | 138.863 | 86.795 | 87.362 | 75.87 | 76.836 | 3.533 |
| 10254 | 120.998 | 121.383 | 89.097 | 90.119 | 83.94 | 84.997 | 0.884 |
| 10282 | 126.724 | 127.551 | 85.749 | 87.406 | 73.878 | 75.412 | 1.53 |
| 10284 | 130.894 | 130.01 | 81.419 | 81.819 | 72.873 | 73.05 | 1.904 |
| 10315 | 126.892 | 127.219 | 93.373 | 93.25 | 82.017 | 81.926 | 0.66 |
| 10344 | 137.947 | 138.836 | 90.393 | 92.325 | 79.225 | 80.546 | 4.218 |
| 10346 | 128.708 | 128.464 | 93.143 | 94.564 | 83.865 | 85.251 | -0.632 |
| 10354 | 128.885 | 130.882 | 87.578 | 89.237 | 79.911 | 80.736 | 3.241 |

| Case ID | Ang a1 | Ang b1 | Ang a2 | Ang b2 | Ang a3 | Ang b3 | Ang a4 |
|---|---|---|---|---|---|---|---|
| 10369 | 133.022 | 133.604 | 93.77 | 93.249 | 86.649 | 85.257 | -1.441 |
| 10392 | 125.987 | 125.559 | 88.301 | 89.6 | 78.18 | 80.5 | 0.396 |
| 10399 | 130.373 | 129.52 | 92.638 | 92.78 | 82.962 | 83.534 | 0.139 |
| 10423 | 127.584 | 126.237 | 81.425 | 80.78 | 73.169 | 73.358 | 0.872 |
| 10445 | 128.195 | 126.639 | 83.922 | 83.136 | 74.813 | 72.857 | 2.741 |
| 10447 | 132.204 | 131.92 | 94.878 | 95.583 | 85.226 | 86.563 | 0.728 |
| 10485 | 144.134 | 143.536 | 89.069 | 88.582 | 77.518 | 77.538 | 3.739 |
| 10491 | 120.271 | 119.339 | 85.469 | 85.522 | 78.829 | 78.275 | -1.198 |
| 10495 | 122.76 | 122.258 | 79.764 | 79.208 | 73.418 | 72.456 | 3.013 |
| 10515 | 129.181 | 130.172 | 87.375 | 88.324 | 81.105 | 81.865 | -0.942 |
| 10517 | 136.872 | 136.574 | 91.15 | 91.602 | 82.004 | 82.662 | -0.271 |
| 10549 | 129.784 | 129.774 | 80.231 | 79.203 | 71.724 | 71.064 | 4.666 |
| 10553 | 128.084 | 127.28 | 81.369 | 80.176 | 76.451 | 76.14 | 0.275 |
| 10554 | 128.999 | 128.329 | 90.008 | 90.79 | 79.544 | 81.714 | 2.977 |
| 10555 | 144.806 | 140.086 | 88.904 | 88.496 | 75.228 | 75.56 | -0.938 |
| 10569 | 128.128 | 128.688 | 89.917 | 90.933 | 81.11 | 82.666 | 1.091 |
| 10570 | 125.519 | 127.976 | 84.236 | 84.276 | 77.099 | 77.322 | 0.825 |
| 10571 | 135.23 | 134.357 | 91.994 | 91.65 | 76.768 | 77.153 | 1.96 |
| 10572 | 127.254 | 125.503 | 77.552 | 76.198 | 69.04 | 68.585 | 3.2 |
| 10573 | 128.786 | 127.601 | 83.13 | 82.653 | 74.779 | 75.123 | 3.028 |
| 10574 | 122.463 | 121.427 | 92.192 | 93.312 | 83.82 | 85.828 | 0.467 |
| 10575 | 129.592 | 129.576 | 87.731 | 89.062 | 80.085 | 81.113 | 3.131 |
| 10576 | 129.137 | 130.53 | 90.482 | 90.806 | 83.517 | 83.294 | 1.146 |
| 10586 | 122.93 | 123.876 | 83.01 | 84.071 | 75.676 | 77.156 | 2.001 |
| 10589 | 121.986 | 122.949 | 89.755 | 90.672 | 77.641 | 78.435 | 4.831 |
| 10595 | 122.81 | 123.658 | 84.212 | 84.142 | 78.775 | 77.702 | 0.589 |
| 10596 | 125.091 | 126.517 | 80.217 | 78.618 | 74.468 | 72.336 | 2.519 |
| 10626 | 133.147 | 133.068 | 79.196 | 78.523 | 68.661 | 68.282 | 3.477 |
| 10627 | 127.58 | 128.457 | 81.842 | 82.433 | 70.322 | 70.445 | 5.255 |
| 10629 | 130.031 | 130.772 | 94.626 | 93.187 | 83.864 | 83.56 | 1.206 |
| 10631 | 134.167 | 134.188 | 88.654 | 88.86 | 77.498 | 77.114 | 0.099 |
| 10638 | 130.991 | 131.463 | 87.725 | 86.424 | 76.587 | 75.57 | 5.854 |
| 10639 | 136.294 | 135.573 | 94.071 | 94.457 | 81.833 | 82.608 | 2.38 |
| 10640 | 123.696 | 124.658 | 81.253 | 81.636 | 75.82 | 76.436 | 2.821 |
| 10642 | 130.939 | 130.619 | 91.683 | 92.019 | 79.032 | 79.063 | 1.404 |
| 10643 | 127.469 | 130.03 | 94.846 | 94.491 | 82.335 | 80.754 | 0.067 |
| 10645 | 138.997 | 134.521 | 90.045 | 89.851 | 79.622 | 78.625 | 4.265 |
| 10646 | 130.705 | 131.113 | 93.28 | 93.936 | 80.766 | 81.513 | -0.159 |
| 10647 | 129.108 | 131.672 | 84.905 | 88.47 | 76.3 | 77.516 | 2.059 |
| 10666 | 129.068 | 123.527 | 84.926 | 86.204 | 80.527 | 82.039 | 1.669 |
| 10667 | 127.341 | 125.643 | 94.198 | 93.417 | 82.988 | 82.632 | -1.433 |

| Case ID | Ang a1 | Ang b1 | Ang a2 | Ang b2 | Ang a3 | Ang b3 | Ang a4 |
|---|---|---|---|---|---|---|---|
| 10670 | 130.477 | 130.277 | 85.476 | 85.269 | 71.342 | 71.581 | 2.78 |
| 10671 | 124.602 | 124.682 | 91.001 | 90.961 | 84.249 | 85.16 | 2.617 |
| 10713 | 136.615 | 136.232 | 86.516 | 87.271 | 77.277 | 75.9 | 2.371 |
| 10714 | 135.228 | 134.528 | 89.252 | 89.418 | 77.875 | 78.172 | 0.29 |
| 10716 | 133.172 | 133.139 | 83.617 | 83.412 | 75.312 | 74.903 | 4.859 |
| 10720 | 132.918 | 133.6 | 90.771 | 91.295 | 79.167 | 81.029 | 2.109 |
| 10732 | 125.878 | 124.553 | 85.534 | 84.488 | 78.386 | 77.451 | 1.448 |
| 10733 | 131.983 | 134.226 | 85.462 | 87.404 | 81.893 | 81.299 | 0.172 |
| 10734 | 128.839 | 129.887 | 86.451 | 87.825 | 81.413 | 83.02 | -3.194 |
| 10736 | 129.907 | 129.525 | 86.064 | 86.502 | 77.247 | 77.286 | -0.308 |
| 10737 | 135.068 | 137.046 | 85.733 | 87.542 | 75.275 | 74.779 | 2.362 |
| 10740 | 130.707 | 127.14 | 88.465 | 86.71 | 79.218 | 78.398 | 1.051 |
| 10741 | 131.238 | 131.227 | 75.417 | 76.486 | 72.971 | 72.023 | 1.809 |
| 10788 | 128.602 | 128.377 | 85.964 | 85.288 | 77.971 | 77.255 | -1.051 |
| 10791 | 130.462 | 130.825 | 81.835 | 81.826 | 74.667 | 73.175 | 2.29 |
| 10793 | 128.649 | 127.148 | 90.066 | 89.663 | 80.285 | 80.666 | 1.932 |
| 10794 | 122.052 | 121.723 | 84.317 | 84.514 | 76.115 | 76.873 | 3.214 |
| 10833 | 137.349 | 134.997 | 97.678 | 96.451 | 84.512 | 83.636 | -2.206 |
| 10837 | 127.572 | 126.995 | 87.704 | 86.999 | 74.121 | 72.024 | 0.666 |
| 10839 | 132.02 | 132.075 | 85.418 | 84.327 | 78.326 | 77.297 | 3.345 |
| 10840 | 126.705 | 126.699 | 85.619 | 84.327 | 76.152 | 74.508 | -0.025 |
| 10877 | 128.59 | 127.883 | 87.182 | 87.05 | 79.91 | 79.32 | 0.426 |
| 10878 | 138.135 | 136.9 | 88.009 | 87.306 | 78.13 | 77.593 | 2.404 |
| 10879 | 135.96 | 133.647 | 87.927 | 86.262 | 78.651 | 77.108 | -0.059 |
| 10882 | 127.618 | 126.729 | 90.686 | 89.475 | 83.733 | 82.559 | -4.927 |
| 10919 | 137.305 | 139.443 | 89.956 | 90.116 | 80.79 | 80.374 | 2.077 |
| 10959 | 129.444 | 127.414 | 88.509 | 87.62 | 81.369 | 81.01 | 2.167 |
| 10960 | 128.722 | 129.687 | 84.906 | 84.664 | 75.415 | 75.504 | 2.928 |
| 10962 | 117.559 | 118.507 | 81.554 | 81.618 | 77.997 | 77.435 | -1.23 |
| 10969 | 131.481 | 131.679 | 89.295 | 89.037 | 80.713 | 80.648 | 2.758 |
| 10989 | 126.305 | 127.134 | 95.279 | 95.49 | 88.862 | 89.718 | -0.1 |
| 10998 | 128.457 | 129.444 | 85.985 | 85.881 | 73.42 | 73.177 | 1.216 |
| 11004 | 127.778 | 128.276 | 85.413 | 85.097 | 80.502 | 80.249 | 0.649 |
| 11048 | 131.305 | 132.442 | 87.546 | 87.356 | 75.632 | 75.991 | 1.334 |
| 11075 | 123.286 | 124.247 | 84.953 | 85.309 | 78.286 | 78.521 | 0.064 |
| 11077 | 127.912 | 129.553 | 86.455 | 87.111 | 76.191 | 77.183 | 1.135 |
| 11080 | 127.648 | 129.266 | 98.298 | 98.526 | 88.04 | 87.067 | 0.873 |
| 11108 | 131.669 | 132.399 | 88.557 | 88.649 | 78.358 | 79.223 | 1.792 |
| 11110 | 125.516 | 127.356 | 92.579 | 94.389 | 84.255 | 85.627 | -2.218 |
| 11146 | 126.848 | 126.216 | 95.018 | 93.831 | 84.132 | 83.584 | -0.641 |
| 11336 | 126.493 | 126.894 | 97.49 | 97.419 | 92.162 | 92.34 | -1.742 |
| 11440 | 132.956 | 132.69 | 78.633 | 78.845 | 68.723 | 70.2 | 1.217 |

## Appendix 5(b)

| Case ID | Ang b4 | Ang a5 | Ang b5 | Ang a6 | Ang b6 | Ang a7 | Ang b7 |
|---|---|---|---|---|---|---|---|
| 1782 | 3.029 | 89.54 | 89.468 | 126.473 | 127.319 | 90.572 | 89.451 |
| 2476 | -2.85 | 92.124 | 92.21 | 135.163 | 132.602 | 84.912 | 85.132 |
| 4005 | 5.695 | 90.171 | 90.945 | 125.221 | 125.018 | 88.883 | 89.776 |
| 4381 | 6.177 | 81.713 | 82.201 | 141.839 | 141.976 | 93.114 | 92.463 |
| 4703 | -1.034 | 84.851 | 86.047 | 127.768 | 129.56 | 83.544 | 81.583 |
| 5105 | 4.022 | 90.03 | 90.274 | 146.6 | 147.794 | 85.449 | 84.542 |
| 5748 | -0.604 | 68.476 | 66 | 101.176 | 103.426 | 96.691 | 96.696 |
| 6229 | 2.998 | 76.99 | 77.017 | 130.989 | 132.36 | 83.901 | 83.104 |
| 6429 | -0.083 | 80.415 | 80.459 | 104.847 | 105.01 | 106.348 | 105.169 |
| 6796 | 0.682 | 91.997 | 92.483 | 131.116 | 133.183 | 92.125 | 92.258 |
| 7702 | 2.875 | 89.269 | 89.298 | 124.114 | 126.085 | 78.632 | 78.22 |
| 7703 | 1.567 | 79.346 | 80.914 | 110.243 | 110.968 | 100.352 | 102.324 |
| 7747 | 1.725 | 88.474 | 89.498 | 118.75 | 117.49 | 100.731 | 100.872 |
| 7749 | 4.537 | 84.649 | 85.114 | 134.094 | 135.282 | 81.793 | 82.363 |
| 7767 | 1.881 | 83.217 | 84.811 | 118.747 | 126.556 | 87.689 | 84.179 |
| 7793 | 5.049 | 83.546 | 82.856 | 132.062 | 130.648 | 95.288 | 96.283 |
| 7856 | 1.522 | 87.652 | 89.266 | 137.148 | 134.113 | 89.311 | 91.172 |
| 7907 | -0.163 | 82.272 | 83.215 | 137.096 | 137.181 | 86.911 | 86.907 |
| 7939 | 3.311 | 90.444 | 91.965 | 129.03 | 130.409 | 94.595 | 96.062 |
| 7947 | 2.109 | 83.149 | 83.222 | 146.435 | 144.275 | 78.19 | 78.93 |
| 7963 | 2.35 | 89.939 | 89.949 | 122.691 | 119.357 | 98.34 | 102.666 |
| 7971 | 0.604 | 90.906 | 89.781 | 131.764 | 130.627 | 88.545 | 88.3 |
| 8014 | 4.665 | 88.018 | 88.334 | 137.597 | 137.455 | 83.424 | 84.74 |
| 8046 | -1.111 | 80.137 | 80.67 | 132.967 | 132.095 | 86.782 | 88.331 |
| 8063 | -2.495 | 89.141 | 89.731 | 129.082 | 128.355 | 93.559 | 93.617 |
| 8081 | 0.288 | 82.844 | 84.786 | 134.124 | 130.979 | 84.637 | 87.742 |
| 8089 | 1.091 | 85.315 | 87.512 | 119.209 | 120.215 | 100.491 | 100.632 |
| 8090 | -0.183 | 87.105 | 87.467 | 122.344 | 123.219 | 97.37 | 95.972 |
| 8121 | 3.066 | 86.534 | 87.734 | 141.032 | 139.587 | 98.038 | 100.175 |
| 8122 | 3.011 | 85.478 | 85.244 | 142.858 | 141.835 | 96.954 | 97.328 |
| 8163 | 1.452 | 84.994 | 85.637 | 126.374 | 128.806 | 94.184 | 96.195 |
| 8244 | 1.654 | 79.847 | 79.798 | 161.288 | 160.539 | 71.683 | 71.776 |
| 8254 | -2.5 | 85.179 | 84.685 | 134.672 | 134.571 | 80.809 | 82.073 |
| 8255 | -0.062 | 85.981 | 86.712 | 128.78 | 131.799 | 94.016 | 93.774 |
| 8258 | -0.939 | 83.708 | 84.982 | 129.866 | 128.62 | 93.741 | 95.778 |
| 8261 | 0.59 | 87.337 | 86.717 | 126.723 | 126.944 | 104.032 | 104.441 |
| 8288 | 0.152 | 87.5 | 86.125 | 144.328 | 142.322 | 87.126 | 88.619 |
| 8293 | -0.317 | 97.252 | 97.041 | 122.773 | 123.489 | 100.787 | 99.433 |
| 8294 | -0.145 | 88.797 | 88.464 | 143.082 | 139.345 | 94.234 | 96.34 |
| 9064 | 2.901 | 89.651 | 89.931 | 136.924 | 137.052 | 89.984 | 89.904 |

| Case ID | Ang b4 | Ang a5 | Ang b5 | Ang a6 | Ang b6 | Ang a7 | Ang b7 |
|---|---|---|---|---|---|---|---|
| 9087 | -3.877 | 86.612 | 85.888 | 144.851 | 144.596 | 81.5 | 79.748 |
| 9088 | 1.223 | 80.728 | 80.567 | 134.53 | 134.158 | 86.146 | 87.304 |
| 9092 | -3.777 | 87.933 | 87.391 | 122.704 | 122.716 | 88.493 | 87.923 |
| 9093 | 1.649 | 88.542 | 87.533 | 137.571 | 137.89 | 84.132 | 84.706 |
| 9124 | -3.195 | 86.2 | 87.331 | 121.915 | 117.431 | 94.409 | 99.321 |
| 9125 | -0.308 | 93.693 | 94.358 | 126.203 | 122.168 | 100.731 | 103.183 |
| 9128 | 2.99 | 84.771 | 83.765 | 146.341 | 146.099 | 85.742 | 86.614 |
| 9129 | 0.541 | 89.048 | 88.122 | 115.808 | 114.264 | 105.553 | 106.134 |
| 9161 | -0.925 | 90.654 | 88.419 | 142.149 | 142.793 | 81.127 | 78.791 |
| 9162 | 2.268 | 91.362 | 92.754 | 134.696 | 134.511 | 91.491 | 92.006 |
| 9163 | -0.297 | 88.518 | 88.955 | 106.643 | 107.943 | 106.828 | 105.836 |
| 9164 | 0.69 | 84.218 | 83.529 | 130.577 | 131.647 | 91.172 | 89.566 |
| 9202 | 2.386 | 92.221 | 92.222 | 155.425 | 153.637 | 78.577 | 80.25 |
| 9244 | -0.153 | 82.175 | 82.427 | 127.387 | 126.021 | 92.355 | 92.634 |
| 9247 | 1.591 | 87.298 | 86.675 | 137.942 | 136.4 | 94.47 | 94.613 |
| 9273 | 1.298 | 89.035 | 89.623 | 124.085 | 125.189 | 90.791 | 90.385 |
| 9274 | 4.422 | 83.672 | 83.438 | 135.434 | 137.834 | 91.24 | 90.552 |
| 9284 | -0.556 | 82.213 | 83.991 | 111.537 | 113.827 | 96.656 | 96.947 |
| 9309 | 2.242 | 85.278 | 85.379 | 140.405 | 140.468 | 91.892 | 92.678 |
| 9340 | 3.016 | 94.038 | 93.922 | 125.356 | 124.556 | 104.211 | 103.953 |
| 9344 | 1.337 | 92.157 | 92.042 | 129.697 | 126.475 | 88.113 | 89.664 |
| 9347 | -2.194 | 82.028 | 81.126 | 122.626 | 132.861 | 82.535 | 83.401 |
| 9382 | 3.483 | 94.116 | 93.312 | 136.997 | 131.591 | 94.757 | 95.636 |
| 9411 | 2.311 | 91.132 | 91.088 | 153.229 | 152.723 | 85.978 | 86.491 |
| 9467 | 1.629 | 93.819 | 94.249 | 135.695 | 133.794 | 86.66 | 85.345 |
| 9479 | 2.268 | 86.405 | 86.565 | 129.849 | 129.318 | 95.525 | 95.573 |
| 9559 | 3.939 | 96.281 | 95.728 | 123.458 | 123.507 | 101.319 | 102.55 |
| 9606 | 0.521 | 89.653 | 89.778 | 138.669 | 141.038 | 80.805 | 81.715 |
| 9650 | 2.472 | 76.168 | 76.124 | 120.258 | 121.016 | 88.795 | 88.538 |
| 9700 | 1.343 | 83.928 | 83.25 | 117.97 | 119.067 | 90.958 | 91.748 |
| 9702 | 0.711 | 80.278 | 81.246 | 128.468 | 127.719 | 90.183 | 90.066 |
| 9713 | 0.639 | 86.171 | 85.76 | 144.581 | 144.733 | 93.198 | 92.683 |
| 9733 | 0.518 | 91.65 | 90.074 | 142 | 138.623 | 79.034 | 80.588 |
| 9872 | 2.416 | 86.84 | 86.306 | 144.014 | 144.642 | 79.293 | 77.783 |
| 9873 | 3.16 | 93.153 | 93.53 | 132.372 | 132.055 | 97.202 | 97.09 |
| 9903 | 0.689 | 96.201 | 96.116 | 131.801 | 137.39 | 93.114 | 93.374 |
| 9910 | 3.147 | 86.549 | 87.314 | 136.08 | 136.259 | 89.46 | 90.626 |
| 9919 | 0.526 | 90.586 | 91.066 | 119.449 | 120.747 | 105.97 | 105.12 |
| 9938 | 1.248 | 78.059 | 79.134 | 135.757 | 133.328 | 90.577 | 91.808 |
| 9945 | 2.615 | 85.86 | 86.429 | 132.977 | 133.007 | 97.372 | 97.948 |
| 9984 | 1.753 | 83.414 | 84.47 | 137.068 | 137.945 | 95.369 | 94.923 |

| Case ID | Ang b4 | Ang a5 | Ang b5 | Ang a6 | Ang b6 | Ang a7 | Ang b7 |
|---|---|---|---|---|---|---|---|
| 9985 | -2.367 | 69.13 | 68.641 | 136.694 | 136.597 | 83.407 | 83.593 |
| 9988 | 2.753 | 89.397 | 88.01 | 127.045 | 127.961 | 88.032 | 87.814 |
| 10047 | 1.92 | 89.843 | 90.738 | 115.142 | 116.623 | 102.601 | 102.294 |
| 10048 | 2.377 | 87.119 | 87.573 | 117.499 | 112.231 | 98.959 | 97.83 |
| 10050 | 0.292 | 83.802 | 83.977 | 130.47 | 130.231 | 78.211 | 78.796 |
| 10071 | 1.313 | 86.17 | 87.529 | 132.26 | 131.841 | 96.107 | 97.872 |
| 10110 | -0.988 | 83.347 | 83.45 | 126.927 | 126.288 | 92.041 | 93.352 |
| 10112 | 1.221 | 90.387 | 90.96 | 161.129 | 157.247 | 81.573 | 83.518 |
| 10133 | -1.684 | 85.07 | 84.907 | 130.247 | 129.312 | 94.992 | 96.693 |
| 10140 | 0.88 | 78.95 | 80.126 | 122.222 | 121.873 | 95.307 | 94.978 |
| 10141 | 1.303 | 88.918 | 89.417 | 134.48 | 133.668 | 95.238 | 97.099 |
| 10174 | 2.12 | 92.359 | 92.671 | 138.909 | 140.262 | 88.195 | 88.45 |
| 10176 | 2.453 | 81.884 | 82.164 | 124.203 | 124.334 | 93.774 | 92.44 |
| 10233 | 3.836 | 89.778 | 90.504 | 123.867 | 125.556 | 97.281 | 95.932 |
| 10254 | 0.859 | 88.125 | 87.562 | 131.885 | 131.988 | 94.127 | 93.698 |
| 10282 | 1.563 | 88.916 | 88.201 | 146.377 | 146.214 | 85.323 | 84.887 |
| 10284 | 2.265 | 88.913 | 88.342 | 142.625 | 141.196 | 82.405 | 83.053 |
| 10315 | 0.95 | 85.11 | 86.129 | 138.045 | 137.541 | 91.083 | 90.84 |
| 10344 | 3.292 | 90.349 | 90.639 | 128.923 | 129.635 | 89.694 | 88.452 |
| 10346 | -0.294 | 80.925 | 81.17 | 121.372 | 118.989 | 88.187 | 90.734 |
| 10354 | 2.394 | 86.395 | 85.629 | 134.004 | 125.737 | 82.442 | 93.634 |
| 10369 | 0.138 | 83.432 | 82.85 | 123.656 | 121.555 | 101.675 | 101.665 |
| 10392 | 0.598 | 81.928 | 82.938 | 148.461 | 148.728 | 88.284 | 89.928 |
| 10399 | -0.498 | 84.318 | 83.633 | 139.115 | 137.666 | 80.54 | 81.074 |
| 10423 | 0.77 | 86.881 | 87.31 | 136.828 | 133.318 | 88.247 | 90.563 |
| 10445 | 3.957 | 88.702 | 87.533 | 149.306 | 145.733 | 72.674 | 76.24 |
| 10447 | 0.378 | 80.024 | 79.71 | 116.722 | 113.679 | 100.283 | 100.212 |
| 10485 | 3.804 | 92.564 | 93.189 | 138.945 | 136.935 | 97.926 | 99.379 |
| 10491 | 0.083 | 88.13 | 87.429 | 142.853 | 149.923 | 93.522 | 91.422 |
| 10495 | 3.666 | 86.543 | 83.534 | 126.12 | 128.183 | 90.124 | 88.002 |
| 10515 | -2.566 | 89.331 | 89.108 | 151.222 | 149.904 | 82.823 | 84.99 |
| 10517 | -0.492 | 87.629 | 87.496 | 148.077 | 150.38 | 94.937 | 91.04 |
| 10549 | 4.027 | 94.282 | 94.019 | 141.237 | 136.918 | 92.412 | 94.451 |
| 10553 | 0.533 | 89.061 | 89.478 | 139.239 | 138.234 | 90.512 | 89.396 |
| 10554 | 3.388 | 85.132 | 85.464 | 127.471 | 127.305 | 92.362 | 93.497 |
| 10555 | -0.689 | 100.479 | 100.088 | 128.044 | 129.153 | 90.394 | 88.684 |
| 10569 | 1.402 | 84.212 | 85.124 | 124.085 | 128.843 | 95.917 | 93.701 |
| 10570 | 1.242 | 88.606 | 90.846 | 111.99 | 111.565 | 103.227 | 102.671 |
| 10571 | 2.381 | 79.557 | 80.477 | 123.723 | 123.181 | 90.193 | 90.192 |
| 10572 | 3.262 | 87.234 | 87.608 | 113.362 | 116.361 | 99.649 | 97.572 |
| 10573 | 3.102 | 91.445 | 92.026 | 132.675 | 130.746 | 86.158 | 86.159 |

| Case ID | Ang b4 | Ang a5 | Ang b5 | Ang a6 | Ang b6 | Ang a7 | Ang b7 |
|---|---|---|---|---|---|---|---|
| 10574 | -0.253 | 89.574 | 88.684 | 106.746 | 104.337 | 110.543 | 110.695 |
| 10575 | 3.403 | 88.305 | 88.502 | 103.762 | 104.401 | 100.863 | 99.638 |
| 10576 | 1.424 | 87.914 | 89.155 | 115.238 | 107.387 | 99.072 | 100.261 |
| 10586 | 1.988 | 86.255 | 86.458 | 124.331 | 122.138 | 89.652 | 90.745 |
| 10589 | 4.62 | 79.123 | 78.833 | 131.111 | 131.523 | 81.826 | 81.86 |
| 10595 | 0.757 | 95.166 | 94.039 | 141.088 | 140.906 | 83.543 | 84.337 |
| 10596 | 2.473 | 88.15 | 88.245 | 152.252 | 150.836 | 88.814 | 88.273 |
| 10626 | 3.273 | 90.375 | 89.911 | 138.08 | 133.294 | 98.408 | 101.458 |
| 10627 | 5.1 | 94.769 | 95.929 | 133.456 | 132.529 | 88.827 | 89.892 |
| 10629 | 1.43 | 79.98 | 80.548 | 133.307 | 132.818 | 90.102 | 89.764 |
| 10631 | 0.39 | 89.882 | 89.325 | 110.454 | 110.121 | 100.953 | 102.759 |
| 10638 | 5.625 | 84.385 | 84.891 | 118.391 | 113.937 | 95.804 | 97.816 |
| 10639 | 2.003 | 86.461 | 90.558 | 109.382 | 106.183 | 101.259 | 103.289 |
| 10640 | 2.04 | 89.927 | 90.317 | 134.358 | 134.198 | 91.293 | 90.274 |
| 10642 | 1.132 | 83.669 | 86.701 | 133.409 | 132.916 | 89.103 | 90.211 |
| 10643 | 0.084 | 75.44 | 77.072 | 117.224 | 115.601 | 93.18 | 93.907 |
| 10645 | 4.955 | 87.949 | 86.145 | 132.437 | 136.949 | 103.373 | 101.09 |
| 10646 | -0.509 | 81.121 | 80.862 | 135.679 | 138.09 | 89.448 | 86.133 |
| 10647 | 1.457 | 79.482 | 79.259 | 140.1 | 137.147 | 80.162 | 83.053 |
| 10666 | 1.132 | 85.533 | 84.016 | 146.433 | 144.208 | 85.354 | 87.311 |
| 10667 | -1.125 | 79.745 | 78.835 | 141.989 | 137.082 | 81.293 | 84.681 |
| 10670 | 2.949 | 82.927 | 82.612 | 129.142 | 127.215 | 88.5 | 91.591 |
| 10671 | 1.517 | 83.301 | 82.156 | 136.985 | 136.126 | 93.198 | 91.551 |
| 10713 | 5.033 | 86.69 | 87.996 | 125.263 | 125.27 | 99.462 | 99.706 |
| 10714 | 1.764 | 85.434 | 85.803 | 120.906 | 118.133 | 96.477 | 97.537 |
| 10716 | 5.774 | 87.381 | 87.581 | 133.899 | 136.056 | 98.466 | 96.599 |
| 10720 | 1.42 | 88.526 | 88.807 | 150.287 | 151.332 | 88.661 | 88.076 |
| 10732 | 2.973 | 90.588 | 89.847 | 130.773 | 130.002 | 99.472 | 99.545 |
| 10733 | 1.517 | 85.578 | 84.386 | 117.391 | 122.814 | 97.177 | 95.166 |
| 10734 | -3.672 | 82.378 | 81.857 | 142.247 | 145.887 | 84.789 | 82.295 |
| 10736 | -0.103 | 81.17 | 81.113 | 122.016 | 117.374 | 96.088 | 95.285 |
| 10737 | 2.157 | 94.699 | 94.292 | 111.283 | 111.139 | 92.604 | 92.26 |
| 10740 | 1.391 | 89.673 | 90.478 | 128.36 | 128.925 | 94.59 | 92.337 |
| 10741 | 1.432 | 97.632 | 97.535 | 141.706 | 142.566 | 85.526 | 84.736 |
| 10788 | -1.647 | 86.902 | 86.724 | 127.676 | 132.554 | 89.194 | 87.527 |
| 10791 | 2.124 | 91.004 | 91.238 | 130.262 | 130.117 | 99.214 | 98.831 |
| 10793 | 1.482 | 88.919 | 88.409 | 136.105 | 134.583 | 89.359 | 94.192 |
| 10794 | 2.808 | 86.026 | 86.612 | 156.55 | 155.339 | 89.783 | 91.098 |
| 10833 | -1.376 | 81.245 | 80.702 | 156.147 | 156.717 | 86.938 | 85.804 |
| 10837 | 1.805 | 87.809 | 86.346 | 132.695 | 134.544 | 90.472 | 88.084 |
| 10839 | 3.369 | 90.71 | 91.002 | 143.005 | 142.6 | 93.186 | 94.98 |

| Case ID | Ang b4 | Ang a5 | Ang b5 | Ang a6 | Ang b6 | Ang a7 | Ang b7 |
|---|---|---|---|---|---|---|---|
| 10840 | -0.025 | 90.271 | 89.395 | 132.24 | 128.489 | 90.167 | 91.387 |
| 10877 | 0.458 | 81.872 | 81.63 | 122.838 | 121.002 | 86.968 | 88.63 |
| 10878 | 3.429 | 88.085 | 87.017 | 133.4 | 135.229 | 90.4 | 88.291 |
| 10879 | -0.413 | 89.144 | 88.147 | 127.139 | 127.056 | 96.263 | 93.483 |
| 10882 | -5.051 | 87.511 | 85.587 | 132.559 | 134.447 | 98.453 | 96.468 |
| 10919 | 1.38 | 87.271 | 87.714 | 150.211 | 149.334 | 92.522 | 94.507 |
| 10959 | 1.174 | 80.979 | 81.225 | 130.513 | 129.665 | 91.129 | 95.149 |
| 10960 | 3.39 | 91.057 | 91.308 | 160.031 | 157.799 | 89.802 | 92.644 |
| 10962 | -1.327 | 89.5 | 89.037 | 115.82 | 116.911 | 100.308 | 99.005 |
| 10969 | 2.581 | 88.337 | 89.015 | 121.251 | 120.093 | 96.354 | 96.936 |
| 10989 | -0.418 | 76.557 | 76.78 | 133.757 | 134.745 | 76.772 | 77.598 |
| 10998 | 2.494 | 81.78 | 82.659 | 118.072 | 112.531 | 93.529 | 90.971 |
| 11004 | 1.201 | 87.008 | 86.974 | 134.378 | 130.384 | 94.741 | 96.866 |
| 11048 | 1.56 | 91.711 | 91.696 | 127.695 | 126.339 | 98.37 | 98.895 |
| 11075 | 0.004 | 87.295 | 87.907 | 131.838 | 128.35 | 95.888 | 98.912 |
| 11077 | 0.991 | 87.281 | 89.398 | 141.454 | 138.884 | 88.517 | 90.492 |
| 11080 | 1.02 | 76.935 | 77.559 | 111.749 | 111.896 | 97.996 | 98.01 |
| 11108 | 2.126 | 78.569 | 78.627 | 123.831 | 122.303 | 88.094 | 90.373 |
| 11110 | -0.981 | 82.493 | 83.393 | 124.763 | 126.033 | 87.855 | 87.989 |
| 11146 | -1.369 | 81.519 | 82.499 | 118.893 | 111.83 | 99.768 | 100.826 |
| 11336 | -2.198 | 81.709 | 82.336 | 112.308 | 112.635 | 91.156 | 92.268 |
| 11440 | 1.023 | 89.12 | 90.59 | 139.541 | 138.654 | 82.021 | 84.209 |

## Appendix 5(c)

| Case ID | Ang a8 | Ang b8 | Ang a9 | Ang b9 | Ang a10 | Ang b10 | Ang a11 |
|---|---|---|---|---|---|---|---|
| 1782 | 114.998 | 113.56 | 131.411 | 133.144 | 8.793 | 7.543 | 36.75 |
| 2476 | 111.389 | 114.237 | 130.284 | 131.379 | 2.049 | 2.457 | 30.585 |
| 4005 | 113.882 | 115.148 | 134.258 | 134.807 | 1.49 | 3.714 | 33.504 |
| 4381 | 87.457 | 88.286 | 126.349 | 127.698 | 15.063 | 14.321 | 47.567 |
| 4703 | 111.759 | 112.827 | 134.021 | 133.385 | 1.98 | 2.535 | 38.909 |
| 5105 | 105.948 | 105.623 | 125.924 | 125.361 | 7.501 | 7.21 | 29.504 |
| 5748 | 110.688 | 110.755 | 129.613 | 128.956 | 0.97 | 2.553 | 52.415 |
| 6229 | 101.182 | 100.796 | 134.585 | 134.49 | 2.285 | 2.954 | 46.214 |
| 6429 | 116.851 | 117.454 | 122.172 | 123.158 | 5.38 | 4.904 | 37.334 |
| 6796 | 112.726 | 108.076 | 129.388 | 128.913 | 4.266 | 1.905 | 28.298 |
| 7702 | 125.895 | 123.362 | 124.697 | 127.13 | 5.337 | 5.096 | 36.696 |
| 7703 | 115.828 | 112.752 | 131.697 | 131.296 | 8.055 | 7.009 | 41.633 |
| 7747 | 110.11 | 112.54 | 127.874 | 128.684 | 4.757 | 5.266 | 35.165 |
| 7749 | 107.201 | 106.166 | 131.995 | 131.681 | 3.832 | 4.463 | 40.744 |
| 7767 | 120.575 | 116.292 | 140.376 | 141.7 | 9.181 | 10.544 | 42.17 |
| 7793 | 108.067 | 107.823 | 128.472 | 128.455 | 14.586 | 13.861 | 39.169 |
| 7856 | 105.715 | 108.806 | 128.707 | 129.512 | 6.671 | 7.384 | 34.497 |
| 7907 | 103.087 | 103.746 | 142.531 | 138.114 | 8.351 | 8.827 | 41.257 |
| 7939 | 112.306 | 109.992 | 129.174 | 128.996 | 5.589 | 5.503 | 29.658 |
| 7947 | 107.522 | 108.049 | 126.319 | 125.917 | 9.411 | 8.815 | 37.263 |
| 7963 | 114.664 | 112.209 | 126.607 | 127.826 | 2.651 | 0.467 | 26.956 |
| 7971 | 113.812 | 115 | 127.192 | 126.917 | 4.442 | 4.807 | 30.322 |
| 8014 | 106.784 | 105.45 | 129.938 | 130.772 | 7.3 | 6.916 | 39.495 |
| 8046 | 100.201 | 100.131 | 132.589 | 132.486 | 2.016 | 2.733 | 42.066 |
| 8063 | 109.272 | 112.395 | 129.569 | 128.929 | 4.588 | 6.99 | 32.676 |
| 8081 | 112.568 | 113.518 | 131.801 | 130.752 | 12.462 | 13.255 | 41.132 |
| 8089 | 114.651 | 115.204 | 126.383 | 129.314 | 7.043 | 8.551 | 32.692 |
| 8090 | 114.284 | 114.713 | 129.226 | 128.554 | 9.558 | 8.53 | 35.56 |
| 8121 | 95.163 | 95.356 | 128.55 | 128.055 | 3.96 | 4.469 | 29.727 |
| 8122 | 97.617 | 98.343 | 131.44 | 131.867 | 13.325 | 13.672 | 35.895 |
| 8163 | 109.187 | 105.316 | 130.33 | 129.305 | 6.958 | 7.547 | 37.214 |
| 8244 | 94.932 | 96.042 | 134.544 | 134.526 | 10.166 | 11.868 | 42.263 |
| 8254 | 115.81 | 115.301 | 129.925 | 127.325 | 5.934 | 5.944 | 34.643 |
| 8255 | 108.873 | 105.232 | 131.286 | 130.054 | 8.532 | 7.682 | 36.863 |
| 8258 | 108.887 | 108.543 | 125.441 | 124.453 | 10.769 | 10.011 | 38.276 |
| 8261 | 103.483 | 105.027 | 122.984 | 122.952 | 0.829 | 2.059 | 26.591 |
| 8288 | 103.557 | 104.579 | 122.138 | 122.471 | 7.598 | 7.747 | 32.587 |
| 8293 | 114.977 | 116.514 | 123.914 | 124.19 | 2.967 | 3.948 | 24.431 |
| 8294 | 99.262 | 102.943 | 117.059 | 116.568 | 2.123 | 3.786 | 25.545 |

| Case ID | Ang a8 | Ang b8 | Ang a9 | Ang b9 | Ang a10 | Ang b10 | Ang a11 |
|---|---|---|---|---|---|---|---|
| 9064 | 102.48 | 101.801 | 122.181 | 122.462 | 6.407 | 5.711 | 37.018 |
| 9087 | 99.83 | 100.253 | 130.095 | 132.062 | 3.406 | 3.193 | 37.225 |
| 9088 | 103.637 | 103.374 | 132.741 | 131.736 | 7.965 | 8.871 | 43.652 |
| 9092 | 114.999 | 115.066 | 128.671 | 127.198 | 4.719 | 4.092 | 38.523 |
| 9093 | 108.76 | 109.058 | 129.154 | 127.598 | 8.269 | 8.152 | 37.806 |
| 9124 | 117.222 | 116.025 | 129.031 | 128.222 | 11.391 | 9.748 | 37.845 |
| 9125 | 109.882 | 112.105 | 121.506 | 121.489 | 2.696 | 2.633 | 25.881 |
| 9128 | 99.718 | 99.124 | 125.355 | 125.4 | 6.963 | 6.947 | 35.162 |
| 9129 | 110.38 | 112.378 | 124.895 | 123.974 | 5.385 | 6.374 | 33.644 |
| 9161 | 107.447 | 108.263 | 131.688 | 133.491 | 1.742 | 1.371 | 31.019 |
| 9162 | 116.407 | 117.592 | 127.135 | 126.374 | 11.193 | 12.418 | 28.598 |
| 9163 | 121.724 | 121.47 | 124.059 | 124.762 | 8.778 | 7.779 | 33.584 |
| 9164 | 108.601 | 109.286 | 128 | 128.764 | 6.502 | 7.396 | 36.152 |
| 9202 | 105.102 | 105.288 | 117.868 | 118.075 | 4.487 | 4.382 | 25.384 |
| 9244 | 107.964 | 105.959 | 125.914 | 126.621 | 11.133 | 7.965 | 43.426 |
| 9247 | 100.036 | 101.126 | 129.622 | 129.436 | 4.655 | 5.09 | 32.208 |
| 9273 | 124.074 | 121.466 | 130.618 | 131.551 | 13.584 | 12.834 | 34.634 |
| 9274 | 103.64 | 100.979 | 125.191 | 124.486 | 7.993 | 7.129 | 37.678 |
| 9284 | 111.66 | 111.339 | 143.488 | 141.374 | 4.832 | 6.162 | 44.979 |
| 9309 | 108.811 | 107.095 | 121.346 | 121.007 | 12.712 | 12.104 | 31.603 |
| 9340 | 107.571 | 110.203 | 124.103 | 124.79 | 7.239 | 8.795 | 30.101 |
| 9344 | 106.668 | 107.122 | 133.201 | 134.772 | -1.592 | -1.485 | 33.931 |
| 9347 | 122.155 | 109.193 | 127.923 | 128.222 | 7.95 | 6.092 | 40.634 |
| 9382 | 109.762 | 114.104 | 120.746 | 121.701 | 7.565 | 8.2 | 26.048 |
| 9411 | 93.849 | 94.125 | 129.262 | 128.921 | 6.05 | 6.049 | 32.994 |
| 9467 | 109.434 | 110.733 | 133.648 | 134.277 | 4.127 | 2.696 | 32.338 |
| 9479 | 103.517 | 102.839 | 138.869 | 140.069 | 10.052 | 9.418 | 41.162 |
| 9559 | 117.424 | 113.62 | 123.404 | 124.036 | 3.844 | 1.651 | 21.642 |
| 9606 | 110.038 | 106.656 | 133.656 | 134.568 | 9.791 | 9.356 | 40.279 |
| 9650 | 99.188 | 101.896 | 138.99 | 138.58 | 2.894 | 5.3 | 54.653 |
| 9700 | 113.358 | 111.335 | 130.033 | 128.869 | 2.292 | 1.844 | 40.006 |
| 9702 | 110.31 | 111.741 | 128.177 | 128.838 | 7.347 | 8.181 | 38.385 |
| 9713 | 102.604 | 101.784 | 117.093 | 116.359 | 10.099 | 9.078 | 29.716 |
| 9733 | 113.756 | 113.657 | 124.007 | 125.098 | 2.992 | 2.184 | 28.202 |
| 9872 | 102.108 | 102.076 | 130.953 | 130.429 | 3.728 | 3.116 | 38.313 |
| 9873 | 104.95 | 105.057 | 124.593 | 123.403 | 3.888 | 3.846 | 29.364 |
| 9903 | 112.669 | 107.342 | 119.071 | 119.647 | 2.131 | 3.355 | 24.547 |
| 9910 | 107.463 | 106.261 | 12[illegible].24 | 123.696 | 6.804 | 6.942 | 33.802 |
| 9919 | 116.12 | 114.397 | 115.705 | 116.072 | 9.738 | 8.46 | 28.199 |
| 9938 | 97.569 | 97.297 | 128.997 | 129.58 | 5.356 | 3.873 | 41.452 |
| 9945 | 108.754 | 107.522 | 129.351 | 128.689 | 11.735 | 10.741 | 32.632 |

| Case ID | Ang a8 | Ang b8 | Ang a9 | Ang b9 | Ang a10 | Ang b10 | Ang a11 |
|---|---|---|---|---|---|---|---|
| 9984 | 100.124 | 99.754 | 120.782 | 121.223 | 9.496 | 9.145 | 36.936 |
| 9985 | 102.701 | 102.255 | 133.785 | 133.774 | 14.927 | 14.911 | 52.125 |
| 9988 | 114.111 | 113.569 | 132.997 | 133.305 | 7.965 | 6.875 | 38.777 |
| 10047 | 120.22 | 118.899 | 125.357 | 126.128 | 6.293 | 7.627 | 28.33 |
| 10048 | 114.705 | 121.431 | 134.379 | 135.466 | 7.212 | 8.173 | 36.049 |
| 10050 | 114.944 | 116.898 | 139.912 | 137.28 | 9.856 | 11.358 | 46.23 |
| 10071 | 106.864 | 107.181 | 124.625 | 125.223 | 8.493 | 9.212 | 33.263 |
| 10110 | 110.291 | 109.068 | 125.855 | 126.955 | 6.528 | 6.118 | 37.269 |
| 10112 | 86.282 | 81.78 | 128.391 | 128.768 | 7.443 | 9.478 | 31.024 |
| 10133 | 101.128 | 101.501 | 127.197 | 126.348 | 3.907 | 4.721 | 37.541 |
| 10140 | 113.592 | 113.31 | 126.863 | 129.197 | 14.268 | 13.912 | 43.147 |
| 10141 | 104.711 | 105.54 | 124.336 | 123.99 | 2.552 | 5.5 | 28.124 |
| 10174 | 106.623 | 103.939 | 139.821 | 138.828 | 8.751 | 8.136 | 35.024 |
| 10176 | 107.439 | 107.108 | 136.421 | 138.498 | 4.904 | 4.614 | 39.487 |
| 10233 | 113.473 | 114.203 | 127.232 | 126.648 | 8.647 | 9.7 | 34.027 |
| 10254 | 105.167 | 104.325 | 124.01 | 123.801 | 4.287 | 3.93 | 33.107 |
| 10282 | 98.907 | 99.798 | 127.443 | 126.234 | 3.799 | 4.539 | 33.192 |
| 10284 | 102.002 | 103.767 | 136.079 | 135.658 | 4.53 | 5.492 | 37.498 |
| 10315 | 97.868 | 100.004 | 120.13 | 120.485 | 0.499 | 2.119 | 33.503 |
| 10344 | 111.397 | 113.242 | 125.035 | 124.059 | 5.442 | 7.713 | 35.428 |
| 10346 | 115.231 | 115.791 | 132.202 | 130.446 | 10.135 | 10.524 | 45.344 |
| 10354 | 106.207 | 106.226 | 131.141 | 129.778 | 1.371 | 4.612 | 38.719 |
| 10369 | 113.585 | 116.848 | 121.022 | 121.175 | 13.708 | 14.492 | 34.792 |
| 10392 | 95.196 | 94.224 | 130.1 | 127.716 | 10.343 | 10.195 | 38.401 |
| 10399 | 106.486 | 107.453 | 126.998 | 126.86 | 5.777 | 5.833 | 39.636 |
| 10423 | 103.782 | 105.136 | 136.146 | 135.665 | 6.428 | 5.461 | 37.571 |
| 10445 | 104.044 | 105.265 | 135.044 | 135.784 | 4.989 | 6.158 | 38.965 |
| 10447 | 112.659 | 113.278 | 125.842 | 125.816 | 10.385 | 8.568 | 40.72 |
| 10485 | 101.165 | 101.159 | 121.958 | 121.908 | 9.063 | 7.963 | 31.027 |
| 10491 | 102.795 | 82.506 | 125.364 | 125.371 | 10.003 | 9.732 | 30.832 |
| 10495 | 119.174 | 119.323 | 134.805 | 135.415 | 9.987 | 10.13 | 34.569 |
| 10515 | 102.177 | 101.669 | 124.489 | 123.644 | 8.087 | 8.531 | 31.865 |
| 10517 | 94.55 | 97.069 | 122.711 | 122.481 | 11.423 | 12.572 | 33.86 |
| 10549 | 98.708 | 103.593 | 125.882 | 127.673 | -1.53 | 1.838 | 26.113 |
| 10553 | 98.374 | 102.542 | 127.799 | 128.558 | -2.707 | -1.094 | 29.168 |
| 10554 | 110.725 | 110.901 | 124.444 | 122.555 | 5.01 | 5.047 | 34.452 |
| 10555 | 118.658 | 119.218 | 124.956 | 124.352 | 10.956 | 9.903 | 33.86 |
| 10569 | 111.762 | 110.209 | 127.656 | 126.172 | 9.337 | 9.858 | 37.573 |
| 10570 | 119.613 | 122.042 | 127.247 | 127.101 | 6.313 | 7.655 | 31.482 |
| 10571 | 111.929 | 112.159 | 129.857 | 129.921 | 7.696 | 7.103 | 41.852 |
| 10572 | 113.58 | 113.505 | 135.705 | 136.88 | -0.152 | 0.516 | 33.256 |

| Case ID | Ang a8 | Ang b8 | Ang a9 | Ang b9 | Ang a10 | Ang b10 | Ang a11 |
|---|---|---|---|---|---|---|---|
| 10573 | 118.063 | 121.217 | 125.346 | 125.287 | 5.372 | 6.062 | 28.476 |
| 10574 | 119.749 | 122.847 | 113.668 | 112.869 | 2.898 | 4.059 | 25.859 |
| 10575 | 122.657 | 121.58 | 129.023 | 128.307 | 4.036 | 2.988 | 36.754 |
| 10576 | 115.35 | 121.783 | 122.502 | 122.838 | 2.644 | 3.075 | 32.984 |
| 10586 | 115.134 | 116.333 | 131.679 | 130.44 | 3.806 | 3.727 | 34.689 |
| 10589 | 103.222 | 103.274 | 132.958 | 132.762 | -1.128 | 0.091 | 42.713 |
| 10595 | 111.254 | 110.312 | 123.93 | 125.222 | 4.026 | 4.919 | 28.142 |
| 10596 | 85.117 | 95.91 | 131.465 | 134.021 | 7.632 | 7.656 | 31.682 |
| 10626 | 102.825 | 105.367 | 130.362 | 131.098 | 8.87 | 9.739 | 29.557 |
| 10627 | 117.133 | 117.586 | 127.881 | 127.176 | 9.139 | 9.616 | 29.723 |
| 10629 | 103.467 | 105.843 | 128.892 | 129.446 | 10.394 | 11.057 | 43.518 |
| 10631 | 110.785 | 110.493 | 126.544 | 126.683 | -2.61 | -1.083 | 35.198 |
| 10638 | 115.909 | 117.394 | 124.999 | 126.79 | 2.828 | 2.36 | 32.724 |
| 10639 | 124.839 | 126.731 | 118.635 | 118.131 | 8.185 | 8.792 | 32.705 |
| 10640 | 106.269 | 112.441 | 124.775 | 124.121 | -2.052 | 2.669 | 26.027 |
| 10642 | 102.117 | 104.387 | 128.216 | 127.708 | 4.528 | 7.24 | 39.898 |
| 10643 | 110.828 | 110.899 | 132.389 | 133.458 | 8.467 | 8.356 | 47.235 |
| 10645 | 101.195 | 100.205 | 123.408 | 123.565 | 10.457 | 11.66 | 33.453 |
| 10646 | 99.612 | 100.64 | 129.241 | 129.438 | 7.26 | 8.237 | 42.521 |
| 10647 | 99.561 | 101.276 | 139.542 | 137.141 | 4.27 | 7.087 | 44.448 |
| 10666 | 93.234 | 95.102 | 128.504 | 127.638 | -1.549 | 0.461 | 33.43 |
| 10667 | 112.361 | 115.803 | 125.175 | 124.771 | 15.015 | 15.753 | 39.372 |
| 10670 | 112.718 | 114.652 | 133.813 | 132.997 | 9.648 | 11.723 | 39.289 |
| 10671 | 107.662 | 110.256 | 121.417 | 121.93 | 10.262 | 10.823 | 32.417 |
| 10713 | 107.004 | 107.696 | 129.562 | 127.566 | 7.807 | 7.508 | 36.078 |
| 10714 | 116.734 | 121.853 | 127.404 | 126.409 | 10.774 | 13.349 | 36.656 |
| 10716 | 102.356 | 100.323 | 129.151 | 129.86 | 7.488 | 6.249 | 32.768 |
| 10720 | 95.809 | 96.319 | 121.429 | 121.105 | 6.958 | 8.127 | 32.2 |
| 10732 | 112.681 | 113.451 | 123.459 | 124.222 | 11.919 | 11.708 | 28.993 |
| 10733 | 113.687 | 109.071 | 130.962 | 130.947 | 4.68 | 5.402 | 36.424 |
| 10734 | 98.11 | 97.391 | 134.917 | 133.994 | 6.514 | 7.391 | 41.368 |
| 10736 | 108.125 | 113.599 | 134.01 | 133.264 | 6.303 | 6.024 | 40.074 |
| 10737 | 126.988 | 127.015 | 127.351 | 126.452 | 3.958 | 4.408 | 33.084 |
| 10740 | 123 | 125.341 | 124.228 | 124.689 | 18.642 | 18.001 | 32.693 |
| 10741 | 113.794 | 113.415 | 128.625 | 128.422 | 5.067 | 5.626 | 24.041 |
| 10788 | 109.067 | 106.772 | 129.174 | 130.37 | 1.075 | 2.51 | 35.137 |
| 10791 | 112.984 | 113.447 | 125.8 | 125.626 | 10.094 | 9.846 | 27.634 |
| 10793 | 104.609 | 104.192 | 123.313 | 122.566 | 3.451 | 5.196 | 33.379 |
| 10794 | 93.085 | 91.755 | 124.626 | 124.734 | 2.192 | 3.93 | 28.943 |
| 10833 | 95.619 | 96.105 | 129.113 | 129.994 | 14.256 | 12.86 | 46.791 |
| 10837 | 108.076 | 108.509 | 127.471 | 129.183 | 6.418 | 7.318 | 35.174 |

| Case ID | Ang a8 | Ang b8 | Ang a9 | Ang b9 | Ang a10 | Ang b10 | Ang a11 |
|---|---|---|---|---|---|---|---|
| 10839 | 104.574 | 103.358 | 124.092 | 124.86 | 10.275 | 10.125 | 29.51 |
| 10840 | 110.486 | 113.322 | 131.087 | 131.859 | 9.599 | 9.383 | 36.706 |
| 10877 | 111.469 | 110.515 | 135.479 | 134.82 | 3.936 | 2.017 | 42.661 |
| 10878 | 104.909 | 105.493 | 131.533 | 133.25 | 8.251 | 9.568 | 39.542 |
| 10879 | 104.26 | 106.455 | 128.778 | 131.067 | 4.368 | 4.323 | 36.705 |
| 10882 | 102.521 | 104.421 | 122.763 | 123.888 | 6.982 | 8.699 | 33.449 |
| 10919 | 97.501 | 96.277 | 121.647 | 121.863 | 11.836 | 12.097 | 31.602 |
| 10959 | 108.575 | 107.943 | 126.776 | 125.399 | 5.502 | 5.776 | 35.285 |
| 10960 | 86.093 | 88.14 | 118.97 | 119.808 | 7.617 | 6.775 | 23.877 |
| 10962 | 120.329 | 119.585 | 128.411 | 129.817 | 6.421 | 6.935 | 29.964 |
| 10969 | 117.162 | 118.453 | 119.703 | 119.738 | 3.765 | 4.256 | 28.998 |
| 10989 | 112.764 | 110.628 | 135.359 | 134.713 | 13.932 | 13.173 | 50.639 |
| 10998 | 113.492 | 121.786 | 134.464 | 134.354 | 5.542 | 5.524 | 40.449 |
| 11004 | 98.381 | 101.119 | 131.428 | 132.165 | 4.34 | 5.63 | 36.84 |
| 11048 | 106.919 | 109.251 | 124.152 | 124.568 | 4.683 | 6.41 | 31.698 |
| 11075 | 99.356 | 100.697 | 129.009 | 127.749 | 1.045 | 1.016 | 33.962 |
| 11077 | 100.341 | 101.229 | 126.916 | 125.903 | 3.683 | 3.619 | 33.371 |
| 11080 | 119.218 | 121.229 | 122.201 | 122.239 | 9.462 | 11.901 | 40.499 |
| 11108 | 111.184 | 111.438 | 138.177 | 137.725 | 9.843 | 10.488 | 46.734 |
| 11110 | 114.456 | 113.529 | 121.121 | 120.08 | 0.775 | 2.02 | 33.7 |
| 11146 | 109.268 | 118.269 | 119.742 | 120.739 | 2.688 | 5.495 | 34.76 |
| 11336 | 117.884 | 116.564 | 123.084 | 122.679 | 1.923 | 1.565 | 40.574 |
| 11440 | 107.993 | 106.799 | 138.682 | 137.473 | 6.87 | 5.98 | 37.315 |

## Appendix 5(d)

| Case ID | Ang b11 | Ang a12 | Ang b12 | Ang a13 | Ang b13 |
|---|---|---|---|---|---|
| 1782 | 37.213 | 25.817 | 26.806 | 27.957 | 29.67 |
| 2476 | 30.487 | 25.067 | 24.623 | 28.536 | 28.03 |
| 4005 | 33.772 | 24.894 | 24.179 | 32.014 | 30.058 |
| 4381 | 48.169 | 32.383 | 32.697 | 32.504 | 33.848 |
| 4703 | 38.565 | 29.747 | 29.428 | 36.929 | 36.03 |
| 5105 | 29.251 | 18.697 | 17.252 | 22.002 | 22.041 |
| 5748 | 51.675 | 46.507 | 45.75 | 51.445 | 49.122 |
| 6229 | 46.693 | 36.693 | 36.272 | 43.928 | 43.739 |
| 6429 | 37.271 | 31.211 | 30.879 | 31.954 | 32.367 |
| 6796 | 28.389 | 20.948 | 20.85 | 24.033 | 26.484 |
| 7702 | 37.429 | 27.891 | 27.721 | 31.359 | 32.333 |
| 7703 | 40.965 | 36.495 | 36.235 | 33.578 | 33.956 |
| 7747 | 34.363 | 22.484 | 20.822 | 30.408 | 29.097 |
| 7749 | 40.652 | 28.542 | 27.885 | 36.912 | 36.189 |
| 7767 | 43.516 | 35.264 | 35.215 | 32.989 | 32.972 |
| 7793 | 39.107 | 27.631 | 27.609 | 24.583 | 25.246 |
| 7856 | 33.293 | 23.389 | 23.179 | 27.826 | 25.908 |
| 7907 | 40.993 | 33.742 | 34.848 | 32.906 | 32.167 |
| 7939 | 29.04 | 19.015 | 19.152 | 24.069 | 23.537 |
| 7947 | 37.56 | 25.973 | 25.532 | 27.852 | 28.746 |
| 7963 | 26.236 | 19.837 | 18.999 | 24.305 | 25.768 |
| 7971 | 30.881 | 23.758 | 24.233 | 25.88 | 26.073 |
| 8014 | 39.272 | 28.449 | 27.908 | 32.195 | 32.355 |
| 8046 | 42.176 | 34.249 | 33.546 | 40.05 | 39.443 |
| 8063 | 32.624 | 27.86 | 28.236 | 28.088 | 25.634 |
| 8081 | 41.015 | 29.278 | 28.426 | 28.67 | 27.76 |
| 8089 | 32.499 | 24.49 | 23.914 | 25.649 | 23.948 |
| 8090 | 34.626 | 25.563 | 25.678 | 26.002 | 26.096 |
| 8121 | 29.35 | 22.358 | 20.79 | 25.767 | 24.881 |
| 8122 | 36.166 | 20.538 | 20.825 | 22.57 | 22.494 |
| 8163 | 37.23 | 28.314 | 27.474 | 30.255 | 29.683 |
| 8244 | 43.511 | 28.394 | 28.773 | 32.097 | 31.643 |
| 8254 | 33.999 | 29.42 | 28.68 | 28.709 | 28.055 |
| 8255 | 36.878 | 28.831 | 28.156 | 28.331 | 29.196 |
| 8258 | 37.071 | 28.539 | 27.402 | 27.506 | 27.06 |
| 8261 | 25.646 | 21.348 | 20.39 | 25.762 | 23.588 |
| 8288 | 32.226 | 23.086 | 22.493 | 24.989 | 24.48 |
| 8293 | 24.514 | 17.387 | 17.561 | 21.463 | 20.565 |
| 8294 | 25.158 | 17.964 | 18.039 | 23.422 | 21.372 |

| Case ID | Ang b11 | Ang a12 | Ang b12 | Ang a13 | Ang b13 |
|---|---|---|---|---|---|
| 9064 | 36.953 | 24.29 | 24.289 | 30.611 | 31.242 |
| 9087 | 38.597 | 29.12 | 30.013 | 33.819 | 35.404 |
| 9088 | 44.035 | 33.221 | 31.337 | 35.687 | 35.164 |
| 9092 | 38.386 | 28.621 | 27.294 | 33.804 | 34.295 |
| 9093 | 36.498 | 22.239 | 21.3 | 29.537 | 28.346 |
| 9124 | 36.972 | 28.214 | 27.735 | 26.455 | 27.224 |
| 9125 | 25.177 | 19.493 | 19.186 | 23.185 | 22.544 |
| 9128 | 35.11 | 28.004 | 27.994 | 28.199 | 28.163 |
| 9129 | 33.597 | 23.744 | 24.339 | 28.259 | 27.224 |
| 9161 | 31.525 | 25.413 | 25.555 | 29.277 | 30.154 |
| 9162 | 28.309 | 22.307 | 21.383 | 17.406 | 15.89 |
| 9163 | 32.53 | 24.352 | 24.121 | 24.806 | 24.751 |
| 9164 | 36.897 | 30.673 | 27.62 | 29.65 | 29.501 |
| 9202 | 25.207 | 13.675 | 13.562 | 20.897 | 20.825 |
| 9244 | 43.351 | 31.748 | 31.744 | 32.293 | 35.386 |
| 9247 | 32.95 | 23.361 | 23.781 | 27.552 | 27.861 |
| 9273 | 35.794 | 26.781 | 27.748 | 21.05 | 22.96 |
| 9274 | 37.765 | 23.644 | 24.412 | 29.685 | 30.635 |
| 9284 | 44.049 | 36.106 | 34.774 | 40.147 | 37.887 |
| 9309 | 31.864 | 22.22 | 21.796 | 18.891 | 19.76 |
| 9340 | 30.083 | 18.998 | 19.817 | 22.862 | 21.288 |
| 9344 | 35.253 | 25.699 | 26.809 | 35.522 | 36.738 |
| 9347 | 40.637 | 34.278 | 33.563 | 32.684 | 34.545 |
| 9382 | 26.87 | 11.895 | 12.851 | 18.483 | 18.67 |
| 9411 | 32.711 | 21.864 | 22.012 | 26.944 | 26.662 |
| 9467 | 32.824 | 22.671 | 23.587 | 28.211 | 30.128 |
| 9479 | 41.688 | 30.345 | 30.357 | 31.109 | 32.27 |
| 9559 | 21.974 | 16.657 | 16.623 | 17.798 | 20.323 |
| 9606 | 39.947 | 27.48 | 29.228 | 30.487 | 30.591 |
| 9650 | 53.851 | 44.082 | 43.772 | 51.759 | 48.55 |
| 9700 | 39.695 | 27.628 | 27.117 | 37.714 | 37.85 |
| 9702 | 38.654 | 29.098 | 28.1 | 31.038 | 30.473 |
| 9713 | 29.878 | 20.055 | 20.326 | 19.617 | 20.8 |
| 9733 | 29.315 | 28.334 | 29.764 | 25.21 | 27.132 |
| 9872 | 38.615 | 27.236 | 26.938 | 34.584 | 35.499 |
| 9873 | 29.643 | 18.515 | 18.327 | 25.476 | 25.798 |
| 9903 | 25.249 | 15.947 | 16.449 | 22.416 | 21.894 |
| 9910 | 33.795 | 24.133 | 24.055 | 26.997 | 26.853 |
| 9919 | 28.196 | 15.839 | 15.916 | 18.461 | 19.736 |
| 9938 | 41.44 | 35.325 | 35.751 | 36.097 | 37.567 |
| 9945 | 32.263 | 22.781 | 23.255 | 20.897 | 21.522 |

| Case ID | Ang b11 | Ang a12 | Ang b12 | Ang a13 | Ang b13 |
|---|---|---|---|---|---|
| 9984 | 36.524 | 22.799 | 22.998 | 27.439 | 27.378 |
| 9985 | 52.466 | 38.531 | 39.779 | 37.198 | 37.555 |
| 9988 | 37.532 | 29.68 | 28.794 | 30.812 | 30.657 |
| 10047 | 29.811 | 20.887 | 22.151 | 22.038 | 22.184 |
| 10048 | 36.682 | 26.572 | 27.486 | 28.837 | 28.508 |
| 10050 | 45.433 | 34.981 | 34.037 | 36.374 | 34.075 |
| 10071 | 32.319 | 23.61 | 23.552 | 24.77 | 23.107 |
| 10110 | 37.409 | 29.271 | 29.388 | 30.741 | 31.291 |
| 10112 | 30.493 | 21.683 | 21.752 | 23.58 | 21.015 |
| 10133 | 37.215 | 29.859 | 29.99 | 33.633 | 32.494 |
| 10140 | 43.751 | 31.273 | 32.372 | 28.88 | 29.839 |
| 10141 | 29.193 | 18.86 | 20.062 | 25.572 | 23.693 |
| 10174 | 35.485 | 24.92 | 25.124 | 26.273 | 27.349 |
| 10176 | 40.732 | 31.027 | 32.462 | 34.583 | 36.118 |
| 10233 | 34.009 | 23.101 | 23.484 | 25.379 | 24.309 |
| 10254 | 33.919 | 27.95 | 28.798 | 28.821 | 29.989 |
| 10282 | 33.64 | 21.32 | 21.646 | 29.393 | 29.101 |
| 10284 | 37.477 | 28.951 | 28.708 | 32.968 | 31.985 |
| 10315 | 33.734 | 22.147 | 22.411 | 33.004 | 31.616 |
| 10344 | 36.385 | 24.259 | 24.605 | 29.986 | 28.671 |
| 10346 | 45.01 | 36.066 | 35.697 | 35.21 | 34.486 |
| 10354 | 39.015 | 31.052 | 30.514 | 37.348 | 34.403 |
| 10369 | 34.424 | 27.671 | 26.432 | 21.084 | 19.932 |
| 10392 | 37.315 | 28.279 | 28.215 | 28.058 | 27.12 |
| 10399 | 39.64 | 29.959 | 30.394 | 33.859 | 33.807 |
| 10423 | 36.445 | 29.315 | 29.023 | 31.143 | 30.984 |
| 10445 | 38.92 | 29.856 | 28.641 | 33.976 | 32.762 |
| 10447 | 41.399 | 31.068 | 32.379 | 30.335 | 32.831 |
| 10485 | 30.49 | 19.476 | 19.446 | 21.964 | 22.527 |
| 10491 | 30.893 | 24.192 | 23.646 | 20.83 | 21.161 |
| 10495 | 34.623 | 28.223 | 27.872 | 24.582 | 24.493 |
| 10515 | 31.968 | 25.594 | 25.509 | 23.778 | 23.437 |
| 10517 | 34.083 | 24.715 | 25.143 | 22.437 | 21.512 |
| 10549 | 26.876 | 17.606 | 18.737 | 27.643 | 25.038 |
| 10553 | 28.734 | 24.25 | 24.698 | 31.875 | 29.828 |
| 10554 | 33.345 | 23.988 | 24.268 | 29.442 | 28.297 |
| 10555 | 32.848 | 20.184 | 19.912 | 22.904 | 22.944 |
| 10569 | 37.104 | 28.766 | 28.838 | 28.235 | 27.246 |
| 10570 | 31.377 | 24.345 | 24.423 | 25.17 | 23.723 |
| 10571 | 41.572 | 26.626 | 27.074 | 34.156 | 34.468 |
| 10572 | 33.078 | 24.745 | 25.464 | 33.409 | 32.562 |

| Case ID | Ang b11 | Ang a12 | Ang b12 | Ang a13 | Ang b13 |
|---|---|---|---|---|---|
| 10573 | 27.939 | 20.125 | 20.409 | 23.104 | 21.878 |
| 10574 | 26.18 | 17.487 | 18.696 | 22.962 | 22.121 |
| 10575 | 37.369 | 29.108 | 29.42 | 32.718 | 34.381 |
| 10576 | 33.643 | 26.019 | 26.132 | 30.34 | 30.568 |
| 10586 | 34.511 | 27.355 | 27.596 | 30.883 | 30.784 |
| 10589 | 43.434 | 30.599 | 31.197 | 43.841 | 43.343 |
| 10595 | 29.364 | 22.705 | 22.925 | 24.115 | 24.445 |
| 10596 | 32.638 | 25.933 | 26.357 | 24.05 | 24.982 |
| 10626 | 29.62 | 19.023 | 19.38 | 20.687 | 19.882 |
| 10627 | 29.609 | 18.203 | 17.621 | 20.584 | 19.993 |
| 10629 | 42.633 | 32.757 | 33.005 | 33.124 | 31.576 |
| 10631 | 35.543 | 24.041 | 23.797 | 37.808 | 36.627 |
| 10638 | 33.213 | 21.586 | 22.36 | 29.896 | 30.853 |
| 10639 | 32.588 | 20.468 | 20.738 | 24.52 | 23.796 |
| 10640 | 25.757 | 20.595 | 20.556 | 28.079 | 23.088 |
| 10642 | 39.727 | 27.248 | 26.771 | 35.37 | 32.487 |
| 10643 | 47.95 | 34.724 | 34.212 | 38.768 | 39.594 |
| 10645 | 33.416 | 23.03 | 22.19 | 22.995 | 21.756 |
| 10646 | 43.374 | 30.007 | 30.95 | 35.261 | 35.137 |
| 10647 | 45.61 | 35.842 | 34.656 | 40.177 | 38.524 |
| 10666 | 33.841 | 29.031 | 29.676 | 34.979 | 33.38 |
| 10667 | 38.188 | 28.162 | 27.403 | 24.358 | 22.435 |
| 10670 | 38.265 | 25.155 | 24.577 | 29.641 | 26.542 |
| 10671 | 32.891 | 25.666 | 27.089 | 22.155 | 22.068 |
| 10713 | 34.837 | 26.838 | 23.465 | 28.271 | 27.329 |
| 10714 | 35.826 | 25.279 | 24.58 | 25.882 | 22.477 |
| 10716 | 33.271 | 24.463 | 24.763 | 25.279 | 27.022 |
| 10720 | 32.4 | 20.596 | 22.134 | 25.242 | 24.273 |
| 10732 | 28.709 | 21.845 | 21.673 | 17.074 | 17.002 |
| 10733 | 38.351 | 32.855 | 32.246 | 31.745 | 32.949 |
| 10734 | 41.818 | 36.33 | 37.013 | 34.854 | 34.427 |
| 10736 | 39.766 | 31.257 | 30.55 | 33.771 | 33.742 |
| 10737 | 33.994 | 22.625 | 21.231 | 29.125 | 29.585 |
| 10740 | 31.398 | 23.445 | 23.087 | 14.051 | 13.397 |
| 10741 | 24.908 | 21.596 | 20.445 | 18.974 | 19.282 |
| 10788 | 35.657 | 27.145 | 27.625 | 34.063 | 33.148 |
| 10791 | 27.451 | 20.466 | 18.801 | 17.54 | 17.606 |
| 10793 | 32.229 | 23.598 | 23.231 | 29.928 | 27.033 |
| 10794 | 29.248 | 20.741 | 21.608 | 26.751 | 25.318 |
| 10833 | 46.444 | 33.625 | 33.63 | 32.535 | 33.584 |
| 10837 | 36.182 | 21.591 | 21.207 | 28.757 | 28.863 |

| Case ID | Ang b11 | Ang a12 | Ang b12 | Ang a13 | Ang b13 |
|---|---|---|---|---|---|
| 10839 | 29.187 | 22.418 | 22.157 | 19.235 | 19.062 |
| 10840 | 36.185 | 27.239 | 26.367 | 27.107 | 26.802 |
| 10877 | 41.87 | 35.389 | 34.14 | 38.725 | 39.853 |
| 10878 | 40.556 | 29.662 | 30.842 | 31.291 | 30.988 |
| 10879 | 37.329 | 27.429 | 28.175 | 32.337 | 33.006 |
| 10882 | 33.362 | 26.496 | 26.446 | 26.467 | 24.664 |
| 10919 | 31.979 | 22.436 | 22.237 | 19.766 | 19.882 |
| 10959 | 33.018 | 28.145 | 26.408 | 29.783 | 27.242 |
| 10960 | 24.472 | 14.385 | 15.311 | 16.26 | 17.697 |
| 10962 | 31.434 | 26.408 | 27.252 | 23.543 | 24.5 |
| 10969 | 28.774 | 20.416 | 20.386 | 25.232 | 24.518 |
| 10989 | 50.202 | 44.221 | 44.43 | 36.707 | 37.029 |
| 10998 | 40.235 | 27.884 | 27.531 | 34.907 | 34.711 |
| 11004 | 37.261 | 31.929 | 32.413 | 32.5 | 31.631 |
| 11048 | 31.924 | 19.784 | 20.559 | 27.015 | 25.514 |
| 11075 | 33.057 | 27.294 | 26.269 | 32.917 | 32.041 |
| 11077 | 33.014 | 23.107 | 23.085 | 29.688 | 29.394 |
| 11080 | 40.765 | 30.241 | 29.306 | 31.037 | 28.865 |
| 11108 | 46.374 | 36.534 | 36.948 | 36.891 | 35.886 |
| 11110 | 34.469 | 25.375 | 25.706 | 32.925 | 32.448 |
| 11146 | 34.57 | 23.873 | 24.323 | 32.071 | 29.075 |
| 11336 | 40.098 | 35.246 | 35.02 | 38.652 | 38.533 |
| 11440 | 36.317 | 27.405 | 27.673 | 30.445 | 30.337 |

## Appendix 6(a)

## Linear Cephalometric Variables (Double Determination)

**Key:**

| | |
|---|---|
| Lin a | initial determination |
| Lin b | second determination |

| | | |
|---|---|---|
| Lin 1 | Linear measurement | SN |
| Lin 2 | Linear measurement | S-Ba |
| Lin 3 | Linear measurement | S-Co |
| Lin 4 | Linear measurement | S-Ar |
| Lin 5 | Linear measurement | S-Go |
| Lin 6 | Linear measurement | SN-PNS |
| Lin 7 | Linear measurement | Ba-N |
| Lin 8 | Linear measurement | N-ANS |
| Lin 9 | Linear measurement | ANS-Me |
| Lin 10 | Linear measurement | N-Me |
| Lin 11 | Linear measurement | 6/PNS-ANS |
| Lin 12 | Linear measurement | Ptm-ANS |
| Lin 13 | Linear measurement | Co-Go |
| Lin 14 | Linear measurement | Ar-Go |
| Lin 15 | Linear measurement | Co-Me |
| Lin 16 | Linear measurement | Ar-Me |
| Lin 17 | Linear measurement | Go-Me |
| Lin 18 | Linear measurement | LI/Go-Me |

| Case ID | Lin a1 | Lin b1 | Lin a2 | Lin b2 | Lin a3 | Lin b3 | Lin a4 |
|---|---|---|---|---|---|---|---|
| 1782 | 72.684 | 72.551 | 42.608 | 42.552 | 24.042 | 24.552 | 31.276 |
| 2476 | 71.886 | 72.551 | 45.008 | 45.877 | 23.948 | 23.981 | 32.399 |
| 4005 | 68.562 | 68.452 | 48.722 | 48.617 | 28.61 | 28.464 | 35.754 |
| 4381 | 70.884 | 71.274 | 40.995 | 42.85 | 18.478 | 18.698 | 25.724 |
| 4703 | 69.862 | 69.133 | 48.893 | 49.221 | 23.29 | 24.652 | 33.762 |
| 5105 | 70.736 | 70.379 | 44.581 | 45.019 | 29.127 | 30.452 | 35.517 |
| 5748 | 64.784 | 63.784 | 45.711 | 49.737 | 24.315 | 24.611 | 35.818 |
| 6229 | 70.327 | 70.184 | 53.412 | 54.192 | 26.031 | 25.531 | 36.857 |
| 6429 | 71.718 | 71.422 | 45.526 | 45.635 | 21.92 | 23.258 | 31.606 |
| 6796 | 74.318 | 73.417 | 49.031 | 49.221 | 30.039 | 28.801 | 37.817 |
| 7702 | 71.079 | 71.979 | 42.422 | 40.433 | 20.491 | 20.232 | 27.601 |
| 7703 | 69.315 | 68.921 | 44.457 | 44.932 | 24.987 | 25.037 | 30.884 |

| Case ID | Lin a1 | Lin b1 | Lin a2 | Lin b2 | Lin a3 | Lin b3 | Lin a4 |
|---|---|---|---|---|---|---|---|
| 7747 | 72.004 | 72.101 | 45.189 | 44.725 | 26.733 | 26.006 | 33.382 |
| 7749 | 75.245 | 75.717 | 49.637 | 49.65 | 26.23 | 27.297 | 35.032 |
| 7767 | 76.363 | 76.685 | 50.134 | 42.399 | 26.517 | 25.817 | 36.353 |
| 7793 | 70.236 | 70.908 | 45.129 | 45.012 | 26.158 | 25.923 | 32.747 |
| 7856 | 70.087 | 70.22 | 47 | 47.321 | 24.723 | 24.891 | 33.709 |
| 7907 | 67.742 | 68.448 | 40.741 | 40.119 | 23.932 | 21.114 | 28.828 |
| 7939 | 77.541 | 77.269 | 44.437 | 44.668 | 25.12 | 26.563 | 34.341 |
| 7947 | 73.788 | 74.205 | 47.043 | 46.679 | 26.004 | 26.457 | 38.893 |
| 7963 | 67.152 | 67.836 | 47.349 | 46.864 | 24.844 | 24.289 | 32.093 |
| 7971 | 66.006 | 67.571 | 46.998 | 45.45 | 23.684 | 23.516 | 33.725 |
| 8014 | 73.066 | 74.169 | 42.836 | 42.071 | 23.564 | 24.857 | 31.134 |
| 8046 | 62.89 | 63.586 | 46.988 | 46.42 | 22.626 | 21.426 | 33.568 |
| 8063 | 72.109 | 72.247 | 48.439 | 46.336 | 24.572 | 24.171 | 33.601 |
| 8081 | 72.638 | 72.999 | 47.748 | 46.734 | 22.177 | 21.766 | 31.204 |
| 8089 | 69.716 | 70.642 | 52.531 | 50.022 | 22.728 | 22.573 | 34.755 |
| 8090 | 71.743 | 71.98 | 49.374 | 49.633 | 20.676 | 21.7 | 32.967 |
| 8121 | 70.93 | 71.354 | 48.144 | 48.069 | 24.522 | 26.316 | 33.381 |
| 8122 | 70.142 | 71.026 | 46.636 | 47.305 | 27.312 | 28.443 | 33.98 |
| 8163 | 72.797 | 73.562 | 47.798 | 46.286 | 21.877 | 23.548 | 32.455 |
| 8244 | 64.576 | 65.322 | 42.127 | 41.005 | 20.007 | 18.703 | 32.175 |
| 8254 | 67.261 | 67.269 | 45.837 | 47.529 | 23.905 | 23.066 | 37.076 |
| 8255 | 72.7 | 73.441 | 45.401 | 45.029 | 24.042 | 22.947 | 33.458 |
| 8258 | 69.124 | 69.571 | 45.145 | 44.862 | 22.941 | 20.835 | 31.678 |
| 8261 | 67.512 | 68.448 | 54.173 | 55.692 | 32.6 | 32.598 | 42.217 |
| 8288 | 68.301 | 68.48 | 46.192 | 46.916 | 22.251 | 21.992 | 33.937 |
| 8293 | 74.164 | 74.917 | 44.753 | 44.667 | 27.533 | 23.898 | 35.369 |
| 8294 | 69.413 | 69.934 | 46.778 | 47.472 | 22.46 | 22.224 | 34.642 |
| 9064 | 72.382 | 72.876 | 43.811 | 44.593 | 27.469 | 27.17 | 33.076 |
| 9087 | 67.993 | 68.527 | 45.793 | 45.868 | 21.151 | 20.117 | 32.759 |
| 9088 | 70.78 | 72.032 | 46.12 | 46.348 | 23.158 | 22.602 | 31.183 |
| 9092 | 70.121 | 69.858 | 43.941 | 42.702 | 16.298 | 15.075 | 27.98 |
| 9093 | 72.617 | 71.966 | 51.778 | 52.166 | 22.206 | 23.701 | 31.011 |
| 9124 | 66.301 | 65.747 | 40.94 | 40.996 | 20.031 | 19.732 | 28.638 |
| 9125 | 72.259 | 72.524 | 50.378 | 50.307 | 24.215 | 23.516 | 31.452 |
| 9128 | 68.801 | 68.507 | 48.774 | 52.311 | 28.93 | 29.027 | 38.044 |
| 9129 | 71.845 | 72.257 | 41.067 | 43.332 | 24.376 | 24.973 | 30.849 |
| 9161 | 72.222 | 71.654 | 47.748 | 50.774 | 25.664 | 26.251 | 35.707 |
| 9162 | 69.044 | 68.765 | 44.268 | 45.374 | 26.705 | 26.397 | 32.33 |
| 9163 | 69.093 | 68.527 | 47.438 | 48.343 | 27.298 | 28.117 | 34.219 |
| 9164 | 69.01 | 68.718 | 49.205 | 48.821 | 23.909 | 24.41 | 33.131 |
| 9202 | 75.518 | 76.669 | 46.682 | 46.11 | 25.49 | 24.41 | 34.877 |

| Case ID | Lin a1 | Lin b1 | Lin a2 | Lin b2 | Lin a3 | Lin b3 | Lin a4 |
|---|---|---|---|---|---|---|---|
| 9244 | 68.222 | 67.738 | 38.722 | 39.154 | 19.581 | 19.502 | 27.853 |
| 9247 | 76.071 | 75.766 | 48.314 | 49.097 | 25.301 | 24.881 | 33.363 |
| 9273 | 76.331 | 76.024 | 49.774 | 49.143 | 27.728 | 27.391 | 35.752 |
| 9274 | 76.412 | 76.486 | 49.443 | 50.886 | 31.653 | 30.845 | 41.332 |
| 9284 | 73.1 | 72.808 | 45.019 | 45.398 | 24.922 | 25.068 | 33.608 |
| 9309 | 76.083 | 76.368 | 51.137 | 51.36 | 29.782 | 28.246 | 38.897 |
| 9340 | 70.227 | 69.658 | 43.403 | 44.048 | 24.501 | 25.363 | 31.135 |
| 9344 | 73.688 | 73.981 | 44.991 | 45.709 | 22.049 | 22.117 | 31.82 |
| 9347 | 69.884 | 70.468 | 45.793 | 48.903 | 21.63 | 21.616 | 33.246 |
| 9382 | 77.779 | 77.208 | 51.56 | 57.866 | 31.448 | 29.495 | 38.18 |
| 9411 | 79.917 | 79.577 | 51.581 | 52.324 | 29.573 | 28.721 | 39.366 |
| 9467 | 73.125 | 72.238 | 50.642 | 52.869 | 26.772 | 26.461 | 32.677 |
| 9479 | 74.377 | 74.157 | 39.554 | 40.137 | 24.711 | 24.767 | 32.208 |
| 9559 | 72.231 | 71.966 | 46.089 | 46.157 | 28.61 | 28.633 | 34.091 |
| 9606 | 66.434 | 66.592 | 38.098 | 38.529 | 18.282 | 19.705 | 25.529 |
| 9650 | 66.819 | 66.769 | 48.187 | 48.439 | 21.108 | 20.949 | 26.308 |
| 9700 | 70.553 | 70.551 | 48.064 | 48.894 | 28.299 | 28.888 | 35.207 |
| 9702 | 67.592 | 67.057 | 45.066 | 44.322 | 22.583 | 22.296 | 31.389 |
| 9713 | 75.634 | 75.906 | 51.798 | 52.016 | 23.798 | 22.383 | 32.883 |
| 9733 | 65.688 | 65.685 | 45.631 | 46.989 | 26.529 | 27.338 | 34.378 |
| 9872 | 76.083 | 76.283 | 49.488 | 49.417 | 31.46 | 30.617 | 39.919 |
| 9873 | 67.632 | 67.923 | 43.074 | 42.88 | 21.881 | 21.616 | 28.452 |
| 9903 | 76.058 | 76.032 | 44.546 | 42.852 | 22.385 | 24.552 | 33.131 |
| 9910 | 75.367 | 76.445 | 47.085 | 47.465 | 21.209 | 21.115 | 32.426 |
| 9919 | 67.109 | 67.06 | 48.893 | 49.17 | 25.257 | 25.643 | 34.993 |
| 9938 | 76.071 | 76.669 | 52.985 | 54.045 | 27.672 | 27.683 | 41.825 |
| 9945 | 78.527 | 78.28 | 54.476 | 54.045 | 28.071 | 26.881 | 39.689 |
| 9984 | 71.056 | 70.878 | 50.452 | 48.584 | 24 | 24.641 | 36.193 |
| 9985 | 66.716 | 66.123 | 46.817 | 47.396 | 23.428 | 22.939 | 35.583 |
| 9988 | 73.729 | 73.334 | 38.73 | 40.119 | 24.588 | 25.051 | 30.92 |
| 10047 | 77.873 | 77.494 | 50.299 | 50.061 | 26.814 | 26.211 | 35.898 |
| 10048 | 69.884 | 70.176 | 45.982 | 45.984 | 24.587 | 24.973 | 31.582 |
| 10050 | 77.117 | 75.685 | 47.622 | 47.99 | 24.943 | 25.144 | 31.338 |
| 10071 | 71.062 | 70.802 | 43.795 | 42.922 | 21.592 | 22.654 | 31.389 |
| 10110 | 72.42 | 71.866 | 47.687 | 47.859 | 18.064 | 18.094 | 29.405 |
| 10112 | 73.688 | 73.396 | 45.592 | 45.309 | 23.66 | 24.762 | 32.343 |
| 10133 | 69.504 | 69.403 | 44.632 | 46.638 | 23.509 | 24.151 | 32.888 |
| 10140 | 70.177 | 70.821 | 46.11 | 44.668 | 26.496 | 26.525 | 33.574 |
| 10141 | 72.956 | 73.091 | 47.835 | 47.482 | 25.662 | 23.517 | 35.139 |
| 10174 | 71.995 | 72.259 | 43.841 | 44.538 | 25.144 | 24.171 | 31.184 |
| 10176 | 71.946 | 71.136 | 51.574 | 51.398 | 25.643 | 26.881 | 33.601 |

| Case ID | Lin a1 | Lin b1 | Lin a2 | Lin b2 | Lin a3 | Lin b3 | Lin a4 |
|---|---|---|---|---|---|---|---|
| 10233 | 71.361 | 71.637 | 51.83 | 51.636 | 28.632 | 29.323 | 35.799 |
| 10254 | 67.36 | 66.824 | 35.796 | 37.42 | 20.017 | 19.537 | 29.633 |
| 10282 | 71.395 | 71.371 | 47.061 | 47.43 | 20.493 | 21.132 | 30.845 |
| 10284 | 72.231 | 72.524 | 47.323 | 50.003 | 28.035 | 28.6 | 35.963 |
| 10315 | 73.099 | 72.519 | 47.247 | 47.552 | 22.23 | 22.707 | 33.643 |
| 10344 | 70.406 | 69.716 | 45.323 | 45.781 | 27.643 | 26.524 | 33.304 |
| 10346 | 72.579 | 72.031 | 45.936 | 45.903 | 22.094 | 22.094 | 32.751 |
| 10354 | 70.777 | 69.591 | 49.913 | 50.483 | 28.235 | 27.825 | 38.839 |
| 10369 | 70.736 | 70.059 | 50.782 | 50.98 | 28.085 | 29.578 | 38.246 |
| 10392 | 72.141 | 72.199 | 48.179 | 47.44 | 24.04 | 24.141 | 34.301 |
| 10399 | 73.135 | 71.663 | 47.359 | 49.4 | 23.232 | 23.232 | 31.807 |
| 10423 | 73.898 | 73.168 | 49.84 | 48.655 | 27.336 | 28.633 | 38.42 |
| 10445 | 72.012 | 70.844 | 45.972 | 47.43 | 23.828 | 25.306 | 29.566 |
| 10447 | 69.638 | 68.952 | 43.706 | 44.538 | 21.115 | 21.786 | 31.128 |
| 10485 | 72.876 | 72.625 | 40.26 | 41.244 | 25.333 | 26.274 | 31.389 |
| 10491 | 71.939 | 71.638 | 44.614 | 46.112 | 21.406 | 22.478 | 29.572 |
| 10495 | 67.253 | 67.261 | 48.743 | 51.806 | 28.511 | 30.001 | 36.76 |
| 10515 | 68.473 | 68.146 | 50.388 | 49.908 | 26.782 | 24.282 | 35.255 |
| 10517 | 72.32 | 72.448 | 46.638 | 44.668 | 21.616 | 22.024 | 31.266 |
| 10549 | 68.215 | 69.111 | 47.727 | 47.072 | 29.329 | 28.368 | 35.164 |
| 10553 | 68.133 | 68.167 | 52.348 | 53.197 | 28.994 | 30.752 | 36.495 |
| 10554 | 67.382 | 67.613 | 45.903 | 46.554 | 24.137 | 24.208 | 33.728 |
| 10555 | 75.072 | 74.096 | 41.344 | 41.289 | 14.386 | 15.668 | 21.351 |
| 10569 | 66.799 | 65.587 | 45.4 | 45.112 | 21.114 | 22.117 | 28.496 |
| 10570 | 69.427 | 69.852 | 48.537 | 49.745 | 23.706 | 23.92 | 34.199 |
| 10571 | 68.194 | 68.089 | 55.786 | 54.878 | 28.576 | 29.361 | 41.075 |
| 10572 | 69.023 | 69.044 | 45.283 | 44.909 | 27.557 | 28.797 | 34.688 |
| 10573 | 70.351 | 69.695 | 44.126 | 44.44 | 26.268 | 26.925 | 32.293 |
| 10574 | 78.438 | 77.811 | 49.778 | 51.87 | 21.941 | 21.941 | 34.649 |
| 10575 | 71.637 | 71.057 | 43.586 | 44.177 | 24.666 | 24.769 | 32.124 |
| 10576 | 71.447 | 71.155 | 48.167 | 46.157 | 23.035 | 23.613 | 32.771 |
| 10586 | 70.518 | 70.534 | 53.743 | 52.763 | 25.917 | 26.684 | 36.473 |
| 10589 | 70.844 | 70.351 | 48.537 | 48.395 | 26.711 | 26.062 | 37.108 |
| 10595 | 68.715 | 70.175 | 49.222 | 49.065 | 21.941 | 20.498 | 32.569 |
| 10596 | 73.148 | 73.163 | 47.784 | 47.951 | 30.072 | 30.001 | 38.261 |
| 10626 | 73.828 | 73.713 | 49.17 | 50.182 | 29.938 | 30.57 | 38.844 |
| 10627 | 73.783 | 73.199 | 46.841 | 46.864 | 26.251 | 26.135 | 34.2 |
| 10629 | 70.991 | 71.428 | 45.423 | 47.477 | 21.7 | 23.037 | 32.502 |
| 10631 | 69.934 | 70.844 | 44.154 | 43.765 | 23.444 | 22.747 | 33.58 |
| 10638 | 73.22 | 73.804 | 53.548 | 53.427 | 33.796 | 34.665 | 40.822 |
| 10639 | 78.496 | 78.361 | 48.494 | 47.359 | 26.721 | 25.769 | 35.938 |

| Case ID | Lin a1 | Lin b1 | Lin a2 | Lin b2 | Lin a3 | Lin b3 | Lin a4 |
|---|---|---|---|---|---|---|---|
| 10640 | 74.609 | 74.025 | 54.553 | 54.764 | 31.099 | 30.358 | 40.433 |
| 10642 | 75.495 | 75.786 | 45.903 | 45.734 | 20.864 | 20.538 | 32.956 |
| 10643 | 77.049 | 77.109 | 48.483 | 46.665 | 19.977 | 20.324 | 33.932 |
| 10645 | 72.304 | 71.836 | 46.936 | 47.512 | 29.254 | 29.292 | 36.292 |
| 10646 | 72.48 | 72.956 | 50.399 | 50.203 | 20.663 | 20.202 | 32.692 |
| 10647 | 68.077 | 68.064 | 50.351 | 50.997 | 25.002 | 23.808 | 32.751 |
| 10666 | 78.678 | 78.396 | 59.798 | 57.067 | 33.249 | 32.771 | 37.42 |
| 10667 | 67.94 | 68.432 | 46.33 | 47.948 | 24.521 | 24.651 | 36.402 |
| 10670 | 76.303 | 76.132 | 49.874 | 49.895 | 27.737 | 28.602 | 35.488 |
| 10671 | 71.784 | 71.354 | 49.581 | 50.228 | 29.28 | 28.066 | 37.255 |
| 10713 | 68.66 | 68.338 | 48.664 | 49.623 | 28.511 | 26.684 | 34.922 |
| 10714 | 69.677 | 70.22 | 44.361 | 45.619 | 25.303 | 26.745 | 32.695 |
| 10716 | 72.531 | 72.012 | 47.226 | 49.622 | 33.663 | 34.636 | 39.966 |
| 10720 | 74.726 | 73.969 | 48.206 | 47.839 | 26.297 | 25.626 | 35.51 |
| 10732 | 68.507 | 69.336 | 41.871 | 44.429 | 23.142 | 25.25 | 32.216 |
| 10733 | 70.534 | 71.468 | 45.508 | 46.932 | 25.626 | 26.6 | 35.071 |
| 10734 | 76.612 | 76.316 | 49.1 | 49.245 | 25.363 | 24.641 | 36.617 |
| 10736 | 73.512 | 73.678 | 48.514 | 49.076 | 24.498 | 25.448 | 32.767 |
| 10737 | 77.194 | 77.194 | 45.621 | 47.36 | 20.658 | 21.835 | 30.847 |
| 10740 | 71.131 | 72.222 | 40.931 | 41.4 | 21.488 | 21.616 | 30.366 |
| 10741 | 72.031 | 71.955 | 46.911 | 47.817 | 32.339 | 32.121 | 39.645 |
| 10788 | 65.163 | 65.555 | 46.852 | 46.881 | 25.917 | 25.817 | 35.528 |
| 10791 | 74.27 | 74.577 | 48.372 | 49.818 | 33.974 | 34.144 | 41.664 |
| 10793 | 66.463 | 65.316 | 45.112 | 47.308 | 24.289 | 25.337 | 32.888 |
| 10794 | 78.079 | 77.509 | 49.09 | 50.402 | 26.711 | 27.191 | 36.175 |
| 10833 | 68.86 | 68.036 | 44.234 | 45.456 | 21.819 | 22.284 | 30.209 |
| 10837 | 77.317 | 77.317 | 47.961 | 49.895 | 21.547 | 22.175 | 32.956 |
| 10839 | 70.201 | 70.505 | 50.052 | 51.412 | 28.094 | 28.673 | 34.459 |
| 10840 | 70.991 | 70.766 | 44.595 | 44.288 | 18.715 | 18.235 | 25.9 |
| 10877 | 69.592 | 70.472 | 48.619 | 50.724 | 25.444 | 25.051 | 34.378 |
| 10878 | 73.167 | 73.29 | 50.69 | 51.062 | 28.16 | 29.561 | 33.054 |
| 10879 | 75.751 | 75.947 | 48.372 | 49.833 | 24.959 | 25.25 | 32.14 |
| 10882 | 64.544 | 64.282 | 43.715 | 44.322 | 15.518 | 16.652 | 26.872 |
| 10919 | 66.398 | 65.61 | 42.054 | 44.052 | 27.261 | 26.944 | 32.726 |
| 10959 | 64.359 | 65.552 | 49.929 | 50.37 | 29.631 | 28.778 | 37.211 |
| 10960 | 70.068 | 70.176 | 51.463 | 52.314 | 27.909 | 29.071 | 36.994 |
| 10962 | 75.035 | 75.463 | 48.083 | 48.018 | 25.246 | 24.881 | 34.411 |
| 10969 | 72.724 | 72.27 | 47.805 | 47.471 | 28.171 | 27.839 | 34.37 |
| 10989 | 70.21 | 70.441 | 49.727 | 47.791 | 23.015 | 23.209 | 32.171 |
| 10998 | 69.459 | 70.409 | 50.202 | 49.722 | 22.406 | 23.66 | 34.282 |
| 11004 | 71.228 | 71.883 | 46.51 | 47.33 | 25.688 | 26.444 | 33.435 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11048 | 71.768 | 71.794 | 46.516 | 46.725 | 24.527 | 24.572 | 34.132 |
| 11075 | 71.806 | 72.519 | 45.234 | 45.389 | 21.514 | 20.949 | 31.816 |
| 11077 | 69.784 | 70.351 | 49.727 | 47.825 | 24.919 | 25.186 | 33.725 |
| 11080 | 71.191 | 72.173 | 52.678 | 51.465 | 27.616 | 26.878 | 38.622 |
| 11108 | 71.528 | 72.418 | 46.998 | 46.554 | 24.386 | 25.662 | 31.411 |
| 11110 | 68.383 | 68.448 | 48.119 | 47.034 | 22.406 | 22.373 | 34.749 |
| 11146 | 71.24 | 71.852 | 50.329 | 49.126 | 24.366 | 23.455 | 39.544 |
| 11336 | 71.015 | 71.2 | 47.154 | 46.985 | 22.177 | 21.636 | 33.558 |
| 11440 | 69.946 | 70.7 | 44.946 | 45.073 | 27.236 | 26.205 | 32.727 |

## Appendix 6(b)

| Case ID | Lin b4 | Lin a5 | Lin b5 | Lin a6 | Lin b6 | Lin a7 | Lin b7 |
|---|---|---|---|---|---|---|---|
| 1782 | 31.492 | 74.897 | 74.164 | 41.927 | 42.403 | 105.573 | 105.287 |
| 2476 | 33.241 | 73.38 | 72.611 | 42.741 | 42.001 | 106.525 | 107.802 |
| 4005 | 35.879 | 74.728 | 74.485 | 48.251 | 45.873 | 107.464 | 107.633 |
| 4381 | 26.599 | 62.64 | 61.804 | 42.671 | 42.097 | 103.434 | 106.696 |
| 4703 | 34.207 | 70.364 | 70.167 | 47.511 | 45.895 | 108.384 | 108.1 |
| 5105 | 36.323 | 73.581 | 73.381 | 44.348 | 43.591 | 105.742 | 105.735 |
| 5748 | 35.829 | 81.533 | 81.02 | 55.152 | 51.938 | 97.979 | 98.617 |
| 6229 | 36.744 | 73.147 | 71.856 | 47.398 | 46.744 | 112.377 | 112.841 |
| 6429 | 31.331 | 78.419 | 77.789 | 45.243 | 44.871 | 105.288 | 104.684 |
| 6796 | 38.287 | 81.109 | 79.672 | 47.34 | 46.573 | 112.478 | 111.274 |
| 7702 | 27.211 | 63.451 | 62.02 | 44.255 | 44.31 | 101.145 | 100.758 |
| 7703 | 31.384 | 71.311 | 71.228 | 45.186 | 44.772 | 100.417 | 100.431 |
| 7747 | 33.604 | 72.489 | 71.795 | 47.053 | 46.657 | 109.046 | 108.538 |
| 7749 | 35.183 | 71.384 | 70.869 | 48.109 | 48.266 | 114.007 | 114.949 |
| 7767 | 35.933 | 78.154 | 76.805 | 47.725 | 46.229 | 113.37 | 108.27 |
| 7793 | 32.823 | 72.683 | 72.317 | 44.326 | 45.496 | 106.355 | 107.446 |
| 7856 | 33.401 | 73.911 | 73.083 | 46.101 | 44.492 | 106.615 | 107.074 |
| 7907 | 26.739 | 65.697 | 63.849 | 38.471 | 37.423 | 95.722 | 96.171 |
| 7939 | 34.679 | 73.437 | 73.12 | 44.752 | 43.547 | 110.996 | 110.996 |
| 7947 | 39.179 | 88.538 | 87.679 | 52.281 | 53.478 | 109.12 | 109.553 |
| 7963 | 31.646 | 74.741 | 75.518 | 41.923 | 42.749 | 102.42 | 102.408 |
| 7971 | 32.899 | 75.809 | 74.026 | 46.937 | 45.816 | 99.686 | 99.31 |
| 8014 | 31.011 | 66.481 | 66.092 | 43.524 | 43.591 | 106.46 | 107.31 |
| 8046 | 33.515 | 75.587 | 74.233 | 47.016 | 46.713 | 97.864 | 98.328 |
| 8063 | 33.31 | 70.822 | 70.303 | 47.316 | 43.909 | 109.455 | 107.719 |
| 8081 | 29.998 | 72.329 | 70.64 | 47.832 | 45.72 | 110.855 | 110.792 |
| 8089 | 36.134 | 72.904 | 72.326 | 43.626 | 41.305 | 108.717 | 108.359 |
| 8090 | 32.783 | 70.502 | 70.385 | 43.169 | 43.187 | 109.25 | 109.418 |
| 8121 | 33.762 | 72.343 | 72.648 | 43.077 | 43.081 | 106.338 | 107.034 |
| 8122 | 33.998 | 74.708 | 74.207 | 44.493 | 44.121 | 109.036 | 110.328 |
| 8163 | 32.023 | 70.2 | 70.591 | 44.292 | 44.327 | 108.658 | 108.615 |
| 8244 | 31.127 | 69.116 | 67.26 | 43.242 | 42.217 | 93.587 | 93.828 |
| 8254 | 36.996 | 76.841 | 76.805 | 49.317 | 50.031 | 96.559 | 98.809 |
| 8255 | 33.363 | 72.145 | 71.448 | 47.322 | 46.561 | 106.068 | 107.148 |
| 8258 | 33.129 | 69.472 | 70.584 | 44.157 | 44.161 | 101.809 | 102.27 |
| 8261 | 42.34 | 83.699 | 84.218 | 49.684 | 48.484 | 110.401 | 111.892 |
| 8288 | 33.766 | 76.993 | 77.64 | 43.242 | 43.682 | 103.694 | 104.594 |
| 8293 | 34.422 | 80.739 | 80.665 | 44.631 | 43.497 | 106.086 | 107.305 |
| 8294 | 33.581 | 73.356 | 73.534 | 43.811 | 42.122 | 103.312 | 103.077 |

| Case ID | Lin b4 | Lin a5 | Lin b5 | Lin a6 | Lin b6 | Lin a7 | Lin b7 |
|---|---|---|---|---|---|---|---|
| 9064 | 33.502 | 70.245 | 69.485 | 46.038 | 45.312 | 109.739 | 110.723 |
| 9087 | 33.017 | 72.388 | 70.775 | 48.55 | 47.782 | 102.211 | 102.822 |
| 9088 | 31.549 | 70.543 | 70.019 | 45.342 | 45.16 | 107.202 | 108.505 |
| 9092 | 27.437 | 74.461 | 73.97 | 51.701 | 51.006 | 101.745 | 101.012 |
| 9093 | 31.516 | 72.847 | 73.163 | 46.229 | 46.588 | 115.481 | 115.097 |
| 9124 | 30.045 | 64.376 | 63.789 | 40.512 | 40.205 | 98.708 | 97.962 |
| 9125 | 31.939 | 75.129 | 74.977 | 44.639 | 44.279 | 110.887 | 110.872 |
| 9128 | 38.033 | 74.201 | 73.005 | 46.177 | 45.877 | 103.637 | 106.678 |
| 9129 | 31.004 | 68.219 | 67.272 | 42.183 | 41.044 | 104.632 | 105.65 |
| 9161 | 36.408 | 76.094 | 74.256 | 46.538 | 45.81 | 105.29 | 105.537 |
| 9162 | 32.139 | 79.017 | 78.388 | 44.266 | 42.021 | 103.725 | 103.907 |
| 9163 | 34.745 | 73.509 | 74.525 | 41.205 | 41.653 | 109.071 | 109.085 |
| 9164 | 33.422 | 71.824 | 71.369 | 44.616 | 43.897 | 105.246 | 104.994 |
| 9202 | 33.601 | 95.828 | 94.548 | 52.374 | 51.567 | 112.197 | 111.542 |
| 9244 | 28.025 | 59.877 | 59.43 | 40.639 | 41.834 | 100.03 | 99.598 |
| 9247 | 33.362 | 78.858 | 76.493 | 48.099 | 47.732 | 113.022 | 112.385 |
| 9273 | 35.361 | 72.309 | 70.394 | 44.624 | 43.893 | 115.82 | 114.656 |
| 9274 | 40.953 | 84.682 | 83.156 | 54.545 | 54.579 | 112.41 | 113.123 |
| 9284 | 33.439 | 68.261 | 67.94 | 43.847 | 43.13 | 108.624 | 108.505 |
| 9309 | 39.007 | 82.355 | 82.241 | 42.861 | 43.704 | 116.31 | 116.844 |
| 9340 | 31.48 | 73.513 | 73.604 | 46.177 | 44.703 | 106.44 | 106.289 |
| 9344 | 32.082 | 74.762 | 73.832 | 48.465 | 46.95 | 105.912 | 106.091 |
| 9347 | 33.039 | 73.699 | 73.163 | 45.001 | 46.184 | 102.789 | 105.586 |
| 9382 | 38.706 | 91.67 | 90.76 | 49.616 | 48.863 | 120.465 | 126.219 |
| 9411 | 39.476 | 85.632 | 85.233 | 50.055 | 50.021 | 122.046 | 122.082 |
| 9467 | 33.479 | 69.554 | 68.396 | 45.784 | 45.435 | 115.5 | 116.467 |
| 9479 | 31.465 | 63.464 | 62.988 | 41.066 | 40.774 | 106.69 | 107.062 |
| 9559 | 34.52 | 77.007 | 76.641 | 43.85 | 44.31 | 107.358 | 105.736 |
| 9606 | 26.055 | 56.373 | 56.235 | 35.818 | 35.884 | 96.569 | 97.249 |
| 9650 | 26.739 | 60.159 | 59.82 | 46.008 | 43.383 | 106.268 | 106.382 |
| 9700 | 35.458 | 82.737 | 81.543 | 51.606 | 50.832 | 111.275 | 111.136 |
| 9702 | 31.41 | 67.877 | 66.536 | 41.567 | 40.082 | 100.59 | 99.641 |
| 9713 | 32.342 | 75.711 | 74.758 | 45.97 | 46.528 | 116.019 | 116.18 |
| 9733 | 33.977 | 78.355 | 77.461 | 43.56 | 44.033 | 96.49 | 97.07 |
| 9872 | 39.725 | 88.548 | 87.589 | 57.223 | 56.544 | 113.663 | 113.535 |
| 9873 | 27.991 | 65.629 | 64.844 | 41.589 | 41.653 | 99.962 | 100.511 |
| 9903 | 33.249 | 77.922 | 76.974 | 48.091 | 46.955 | 107.513 | 106.166 |
| 9910 | 31.615 | 81.725 | 80.105 | 47.417 | 46.861 | 111.106 | 112.649 |
| 9919 | 35.033 | 76.954 | 76.599 | 48.015 | 47.999 | 106.415 | 106.876 |
| 9938 | 41.07 | 79.098 | 78.88 | 51.579 | 50.817 | 113.135 | 115.68 |
| 9945 | 39.79 | 91.341 | 90.095 | 49.098 | 48.219 | 121.2 | 118.154 |

| Case ID | Lin b4 | Lin a5 | Lin b5 | Lin a6 | Lin b6 | Lin a7 | Lin b7 |
|---|---|---|---|---|---|---|---|
| 9984 | 35.362 | 79.339 | 78.419 | 47.445 | 46.903 | 111.336 | 109.675 |
| 9985 | 34.999 | 77.992 | 76.941 | 47.683 | 46.69 | 103.781 | 103.411 |
| 9988 | 31.549 | 65.41 | 65.643 | 41.489 | 41.52 | 103.711 | 103.402 |
| 10047 | 35.737 | 76.412 | 75.206 | 48.533 | 47.336 | 114.502 | 114.998 |
| 10048 | 32.092 | 68.526 | 67.819 | 41.924 | 41.222 | 106.374 | 106.599 |
| 10050 | 32.502 | 71.167 | 70.395 | 47.844 | 45.579 | 116.297 | 115.231 |
| 10071 | 32.353 | 71.347 | 70.705 | 40.896 | 39.876 | 102.605 | 101.667 |
| 10110 | 30.469 | 75.963 | 76.029 | 46.316 | 45.984 | 105.647 | 105.249 |
| 10112 | 32.999 | 75.106 | 75.257 | 43.893 | 41.607 | 109.735 | 108.867 |
| 10133 | 33.502 | 67.272 | 67.63 | 45.198 | 44.734 | 104.005 | 105.856 |
| 10140 | 32.926 | 72.291 | 71.483 | 42.097 | 42.012 | 108.073 | 106.911 |
| 10141 | 34.796 | 84.424 | 83.688 | 48.791 | 47.274 | 108.588 | 109.282 |
| 10174 | 31.011 | 59.098 | 58.172 | 42.021 | 42.01 | 104.994 | 106.081 |
| 10176 | 34.227 | 70.726 | 69.46 | 47.714 | 47.754 | 111.448 | 111.122 |
| 10233 | 34.751 | 80.813 | 79.991 | 45.435 | 44.276 | 115.363 | 115.629 |
| 10254 | 29.753 | 64.046 | 63.248 | 40.115 | 40.183 | 91.117 | 92.033 |
| 10282 | 31.49 | 75.158 | 73.783 | 46.979 | 46.961 | 106.443 | 107.242 |
| 10284 | 36.803 | 72.952 | 72.856 | 49.622 | 48.477 | 109.235 | 111.458 |
| 10315 | 33.786 | 76.446 | 76.004 | 50.385 | 48.858 | 108.27 | 108.129 |
| 10344 | 33.176 | 71.88 | 70.865 | 47.935 | 45.915 | 108.397 | 108.451 |
| 10346 | 32.751 | 76.457 | 74.717 | 49.673 | 48.926 | 107.46 | 106.813 |
| 10354 | 37.569 | 77.775 | 77.636 | 50.771 | 48.092 | 109.252 | 109.499 |
| 10369 | 38.199 | 76.029 | 75.799 | 45.186 | 44.752 | 111.732 | 111.506 |
| 10392 | 34.416 | 76.94 | 76.963 | 46.293 | 46.381 | 107.75 | 106.99 |
| 10399 | 32.452 | 68.552 | 69.526 | 43.155 | 43.527 | 109.903 | 109.916 |
| 10423 | 38.776 | 82.149 | 82.149 | 49.603 | 49.542 | 111.525 | 109.222 |
| 10445 | 31.012 | 71.131 | 72.05 | 46.242 | 45.085 | 106.738 | 106.202 |
| 10447 | 32.277 | 71.618 | 71.173 | 41.804 | 43.272 | 104.158 | 104.121 |
| 10485 | 32.263 | 72.664 | 72.355 | 41.804 | 42.213 | 108.107 | 108.597 |
| 10491 | 31.067 | 68.795 | 68.795 | 40.856 | 41.222 | 101.987 | 102.447 |
| 10495 | 38.037 | 75.155 | 76.428 | 45.042 | 45.039 | 102.208 | 104.535 |
| 10515 | 35.136 | 72.766 | 72.575 | 45.099 | 45.062 | 107.643 | 107.343 |
| 10517 | 31.741 | 72.255 | 71.911 | 45.251 | 44.973 | 111.033 | 109.291 |
| 10549 | 35.488 | 74.564 | 74.086 | 47.799 | 45.099 | 105.346 | 105.615 |
| 10553 | 37.765 | 80.724 | 80.513 | 50.767 | 48.886 | 108.546 | 108.948 |
| 10554 | 33.728 | 77.03 | 76.953 | 44.752 | 44.691 | 102.667 | 103.165 |
| 10555 | 22.198 | 68.443 | 69.331 | 41.706 | 43.193 | 111.437 | 109.032 |
| 10569 | 28.894 | 67.152 | 67.11 | 42.829 | 42.035 | 101.332 | 100.178 |
| 10570 | 34.649 | 73.493 | 73.795 | 45.691 | 44.659 | 105.316 | 107.843 |
| 10571 | 40.601 | 83.798 | 83.288 | 51.417 | 51.557 | 114.735 | 113.457 |
| 10572 | 35.8 | 72.326 | 71.842 | 45.428 | 45.454 | 102.951 | 101.908 |

| Case ID | Lin b4 | Lin a5 | Lin b5 | Lin a6 | Lin b6 | Lin a7 | Lin b7 |
|---|---|---|---|---|---|---|---|
| 10573 | 32.442 | 83.813 | 84.287 | 44.033 | 43.591 | 103.853 | 103.014 |
| 10574 | 35.359 | 85.463 | 85.176 | 51.594 | 51.557 | 113.234 | 113.816 |
| 10575 | 32.926 | 72.791 | 72.856 | 46.565 | 46.566 | 104.936 | 104.883 |
| 10576 | 32.926 | 74.843 | 73.845 | 46.61 | 46.61 | 108.485 | 107.062 |
| 10586 | 36.27 | 76.565 | 76.302 | 48.505 | 48.516 | 109.461 | 109.122 |
| 10589 | 36.05 | 79.491 | 78.693 | 52.753 | 51.689 | 104.964 | 104.856 |
| 10595 | 31.331 | 72.819 | 71.307 | 46.183 | 45.039 | 103.971 | 105.586 |
| 10596 | 39.032 | 72.944 | 72.524 | 45.454 | 45.062 | 107.948 | 108.754 |
| 10626 | 39.516 | 76.426 | 76.224 | 42.593 | 42.511 | 113.284 | 114.034 |
| 10627 | 35.003 | 72.482 | 72.326 | 40.496 | 40.484 | 108.874 | 108.726 |
| 10629 | 32.14 | 68.332 | 68.543 | 40.256 | 39.722 | 106.071 | 108.56 |
| 10631 | 33.413 | 76.58 | 76.084 | 49.307 | 49.292 | 105.562 | 106.096 |
| 10638 | 41.958 | 80.361 | 79.991 | 50.847 | 51.229 | 115.638 | 116.289 |
| 10639 | 35.502 | 77.843 | 77.414 | 48.561 | 46.516 | 118.393 | 116.977 |
| 10640 | 40.274 | 82.93 | 83.048 | 50.805 | 46.206 | 114.275 | 114.409 |
| 10642 | 33.225 | 69.791 | 69.201 | 46.04 | 44.057 | 111.122 | 111.122 |
| 10643 | 34.587 | 78.626 | 78.279 | 50.89 | 51.727 | 113.278 | 112.926 |
| 10645 | 36.378 | 79.871 | 79.032 | 43.941 | 42.488 | 112.04 | 110.472 |
| 10646 | 32.616 | 73.23 | 72.577 | 45.984 | 44.966 | 112.062 | 112.515 |
| 10647 | 32.751 | 64.76 | 64.511 | 45.251 | 44.208 | 107.211 | 108.852 |
| 10666 | 39.81 | 88.108 | 88.641 | 60.331 | 59.196 | 125.285 | 119.769 |
| 10667 | 36.998 | 78.993 | 79.699 | 46.624 | 45.75 | 102.864 | 103.952 |
| 10670 | 36.794 | 75.635 | 75.604 | 49.82 | 48.407 | 115.11 | 114.878 |
| 10671 | 37.557 | 88.188 | 87.673 | 49.323 | 48.858 | 107.95 | 108.134 |
| 10713 | 35.053 | 73.604 | 73.722 | 42.488 | 42.892 | 109.265 | 109.682 |
| 10714 | 33.611 | 76.865 | 76.974 | 40.665 | 39.905 | 105.884 | 107.26 |
| 10716 | 40.516 | 77.556 | 77.145 | 45.805 | 46.624 | 110.354 | 111.958 |
| 10720 | 35.362 | 81.637 | 81.1 | 53.169 | 51.713 | 113.198 | 112.431 |
| 10732 | 32.692 | 72.063 | 72.104 | 40.496 | 40.484 | 99.039 | 101.37 |
| 10733 | 35.334 | 74.257 | 73.49 | 45.48 | 46.624 | 106.49 | 109.495 |
| 10734 | 35.479 | 77.578 | 77.954 | 48.095 | 47.328 | 114.01 | 114.32 |
| 10736 | 33.405 | 69.951 | 70.067 | 42.812 | 43.297 | 111.056 | 111.531 |
| 10737 | 31.492 | 77.187 | 76.397 | 46.947 | 47.329 | 114.134 | 116.419 |
| 10740 | 30.858 | 75.845 | 76.08 | 38.357 | 37.949 | 102.628 | 102.667 |
| 10741 | 39.159 | 77.145 | 76.831 | 46.624 | 46.206 | 108.83 | 109.54 |
| 10788 | 35.661 | 72.568 | 72.127 | 47.725 | 47.804 | 101.247 | 101.545 |
| 10791 | 42.23 | 85.11 | 84.792 | 49.622 | 49.632 | 111.886 | 113.584 |
| 10793 | 34.173 | 70.756 | 72.255 | 45.48 | 43.955 | 100.983 | 101.174 |
| 10794 | 37.337 | 84.489 | 85.248 | 49.632 | 49.632 | 112.135 | 112.5 |
| 10833 | 31.011 | 65.024 | 65.09 | 45.454 | 45.16 | 105.731 | 105.207 |
| 10837 | 33.699 | 72.29 | 71.228 | 47.209 | 46.799 | 113.139 | 114.5 |

| Case ID | Lin b4 | Lin a5 | Lin b5 | Lin a6 | Lin b6 | Lin a7 | Lin b7 |
|---|---|---|---|---|---|---|---|
| 10839 | 35.128 | 73.357 | 73.357 | 45.443 | 45.062 | 110.171 | 111.679 |
| 10840 | 26.958 | 68.029 | 68.383 | 40.256 | 41.016 | 103.986 | 103.514 |
| 10877 | 34.52 | 73.783 | 74.104 | 47.328 | 49.24 | 106.9 | 109.221 |
| 10878 | 33.479 | 74.989 | 74.353 | 49.026 | 47.999 | 115.961 | 115.947 |
| 10879 | 32.762 | 74.077 | 73.787 | 48.699 | 48.622 | 115.525 | 116.085 |
| 10882 | 28.119 | 67.207 | 66.902 | 40.416 | 40.589 | 97.577 | 97.49 |
| 10919 | 33.657 | 71.436 | 70.554 | 40.801 | 40.501 | 101.399 | 103.136 |
| 10959 | 36.295 | 80.133 | 81.12 | 48.933 | 48.505 | 103.529 | 104.146 |
| 10960 | 37.562 | 79.653 | 78.367 | 43.093 | 43.515 | 109.86 | 111.132 |
| 10962 | 34.51 | 80.955 | 79.289 | 46.177 | 45.825 | 106.211 | 107.047 |
| 10969 | 34.999 | 72.258 | 71.398 | 43.259 | 43.565 | 110.361 | 109.722 |
| 10989 | 32.569 | 63.741 | 63.47 | 47.032 | 46.744 | 107.408 | 106.35 |
| 10998 | 34.173 | 76.557 | 76.114 | 48.684 | 48.622 | 108.084 | 108.986 |
| 11004 | 33.384 | 69.334 | 67.863 | 45.203 | 44.243 | 106.28 | 107.807 |
| 11048 | 34.408 | 78.883 | 78.079 | 50.789 | 49.517 | 108.266 | 108.928 |
| 11075 | 30.923 | 76.856 | 76.305 | 46.927 | 46.95 | 103.767 | 104.994 |
| 11077 | 34.452 | 80.356 | 78.989 | 46.742 | 45.936 | 107.736 | 107.338 |
| 11080 | 37.271 | 79.351 | 78.219 | 49.263 | 47.688 | 111.466 | 112.07 |
| 11108 | 31.034 | 65.622 | 64.98 | 43.048 | 43.036 | 108.605 | 109.354 |
| 11110 | 33.272 | 74.997 | 73.124 | 46.228 | 45.435 | 103.994 | 103.943 |
| 11146 | 40.254 | 78.394 | 76.76 | 50.826 | 49.021 | 109.126 | 108.384 |
| 11336 | 33.259 | 67.969 | 68.03 | 46.228 | 46.242 | 106.065 | 106.272 |
| 11440 | 31.989 | 70.984 | 69.985 | 45.497 | 44.818 | 105.817 | 106.543 |

## Appendix 6(c)

| Case ID | Lin a8 | Lin b8 | Lin a9 | Lin b9 | Lin a10 | Lin b10 | Lin a11 |
|---|---|---|---|---|---|---|---|
| 1782 | 50.304 | 49.487 | 69.932 | 69.954 | 119.528 | 118.636 | 24.861 |
| 2476 | 44.539 | 44.492 | 65.245 | 64.789 | 108.816 | 108.282 | 23.166 |
| 4005 | 49.67 | 49.362 | 66.772 | 66.989 | 115.964 | 115.769 | 20.418 |
| 4381 | 55.131 | 55.114 | 64.159 | 63.742 | 117.113 | 116.413 | 19.722 |
| 4703 | 50.069 | 48.791 | 66.999 | 67.738 | 116.964 | 116.18 | 21.546 |
| 5105 | 50.575 | 50.123 | 59.62 | 59.758 | 110.028 | 109.478 | 20.019 |
| 5748 | 56.215 | 54.277 | 84.967 | 85.764 | 137.744 | 136.312 | 24.643 |
| 6229 | 49.701 | 49.618 | 83.215 | 82.571 | 131.812 | 130.41 | 26.155 |
| 6429 | 50.507 | 49.704 | 72.777 | 72.903 | 122.017 | 121.301 | 23.463 |
| 6796 | 51.424 | 48.646 | 66 | 67.758 | 117.272 | 116.119 | 21.556 |
| 7702 | 49.231 | 48.979 | 61.008 | 60.736 | 110.053 | 109.617 | 17.753 |
| 7703 | 52.084 | 50.847 | 70.024 | 69.507 | 117.973 | 116.412 | 18.867 |
| 7747 | 52.048 | 52.093 | 63.903 | 62.893 | 115.516 | 114.01 | 19.618 |
| 7749 | 52.52 | 53.26 | 71.288 | 69.848 | 123.198 | 122.691 | 19.24 |
| 7767 | 56.303 | 56.216 | 74.632 | 74.328 | 129.532 | 128.387 | 23.226 |
| 7793 | 56.665 | 56.637 | 64.519 | 64.449 | 119.28 | 118.935 | 21.222 |
| 7856 | 51.943 | 51.148 | 65.353 | 63.745 | 116.442 | 113.957 | 21.54 |
| 7907 | 45.158 | 44.783 | 62.104 | 62.055 | 106.084 | 105.52 | 21.11 |
| 7939 | 49.657 | 48.926 | 62.566 | 62.32 | 111.384 | 110.277 | 18.855 |
| 7947 | 61.075 | 61.377 | 76.87 | 76.763 | 137.922 | 138.105 | 26.962 |
| 7963 | 44.346 | 43.272 | 61.227 | 61.917 | 105.253 | 104.912 | 23.49 |
| 7971 | 50.81 | 50.003 | 61.502 | 61.543 | 111.709 | 111.053 | 19.753 |
| 8014 | 50.337 | 50.276 | 66.375 | 65.869 | 116.027 | 115.393 | 18.135 |
| 8046 | 49.273 | 49.661 | 72.723 | 71.435 | 121.827 | 120.915 | 23.607 |
| 8063 | 51.591 | 50.423 | 59.846 | 60.565 | 109.807 | 109.35 | 17.369 |
| 8081 | 58.488 | 57.288 | 63.851 | 63.904 | 121.385 | 120.335 | 19.233 |
| 8089 | 49.657 | 48.942 | 62.994 | 62.782 | 112.089 | 111.179 | 18.866 |
| 8090 | 51.542 | 50.767 | 62.161 | 61.917 | 113.136 | 112.027 | 18.464 |
| 8121 | 46.629 | 47.033 | 61.246 | 60.749 | 106.417 | 106.543 | 18.927 |
| 8122 | 56.245 | 56.63 | 60.557 | 60.262 | 116.029 | 116.229 | 20.842 |
| 8163 | 50.415 | 50.871 | 66.671 | 66.554 | 115.381 | 116.165 | 20.82 |
| 8244 | 51.365 | 51.725 | 61.997 | 63.308 | 112.748 | 114.589 | 22.376 |
| 8254 | 54.225 | 54.868 | 64.771 | 64.181 | 118.724 | 118.837 | 19.545 |
| 8255 | 54.709 | 53.541 | 63.583 | 64.702 | 116.54 | 116.509 | 17.045 |
| 8258 | 53.465 | 53.08 | 62.566 | 63.047 | 114.93 | 114.81 | 18.902 |
| 8261 | 50.392 | 50.453 | 66.801 | 66.074 | 116.527 | 116.04 | 22.315 |
| 8288 | 50.122 | 50.008 | 67.269 | 67.61 | 117.303 | 117.246 | 23.478 |
| 8293 | 47.781 | 47.765 | 64.82 | 64.867 | 112.525 | 112.533 | 21.931 |
| 8294 | 45.784 | 45.815 | 57.842 | 57.811 | 103.178 | 103.139 | 17.369 |

| Case ID | Lin a8 | Lin b8 | Lin a9 | Lin b9 | Lin a10 | Lin b10 | Lin a11 |
|---|---|---|---|---|---|---|---|
| 9064 | 52.32 | 51.066 | 67.626 | 67.738 | 119.838 | 118.423 | 20.385 |
| 9087 | 51.658 | 51.035 | 64.995 | 64.998 | 116.331 | 115.726 | 20.002 |
| 9088 | 52.315 | 53.061 | 73.096 | 71.984 | 123.447 | 123.325 | 22.709 |
| 9092 | 55.818 | 54.619 | 68.959 | 68.748 | 123.935 | 122.403 | 19.615 |
| 9093 | 53.999 | 53.933 | 67.57 | 66.402 | 121.448 | 120.096 | 22.43 |
| 9124 | 49.67 | 48.505 | 58.473 | 57.872 | 106.311 | 104.691 | 17.887 |
| 9125 | 47.46 | 47.209 | 59.997 | 58.927 | 107.279 | 105.993 | 18.848 |
| 9128 | 52.36 | 51.922 | 64.761 | 64.678 | 116.051 | 115.351 | 19.266 |
| 9129 | 47.34 | 47.078 | 62.401 | 61.817 | 108.515 | 107.864 | 17.308 |
| 9161 | 48.333 | 47.346 | 65.884 | 65.462 | 114.095 | 112.671 | 20.019 |
| 9162 | 53.157 | 52.77 | 60.364 | 59.875 | 113.115 | 112.405 | 21.493 |
| 9163 | 49.252 | 48.869 | 67.121 | 67.458 | 114.778 | 114 | 22.048 |
| 9164 | 50.225 | 50.118 | 65.471 | 65.589 | 115.622 | 115.518 | 22.919 |
| 9202 | 57.128 | 55.898 | 73.288 | 72.86 | 130.342 | 128.696 | 24.247 |
| 9244 | 49.619 | 48.164 | 61.692 | 62.867 | 110.115 | 109.054 | 16.562 |
| 9247 | 52.468 | 52.372 | 65.793 | 65.469 | 116.953 | 116.272 | 18.882 |
| 9273 | 57.027 | 55.989 | 60.944 | 61.481 | 117.234 | 116.528 | 19.197 |
| 9274 | 62.442 | 61.838 | 72.645 | 72.482 | 134.244 | 132.718 | 25.811 |
| 9284 | 48.674 | 49.204 | 71.244 | 70.651 | 117.817 | 117.07 | 20.437 |
| 9309 | 55.199 | 55.517 | 68.994 | 68.947 | 123.561 | 123.511 | 23.261 |
| 9340 | 52.468 | 52.319 | 59.681 | 59.629 | 111.816 | 111.08 | 18.957 |
| 9344 | 47.014 | 45.861 | 70.794 | 71.647 | 117.603 | 116.969 | 20.393 |
| 9347 | 51.869 | 51.512 | 71.699 | 71.17 | 122.598 | 121.538 | 21.736 |
| 9382 | 57.356 | 57.079 | 70.067 | 69.953 | 127.39 | 126.885 | 26.007 |
| 9411 | 56.348 | 56.031 | 76.015 | 75.051 | 132.073 | 130.788 | 25.043 |
| 9467 | 49.771 | 48.067 | 60.196 | 61.16 | 109.602 | 108.581 | 19.339 |
| 9479 | 50.031 | 49.307 | 63.774 | 64.086 | 113.13 | 112.383 | 19.311 |
| 9559 | 46.997 | 45.861 | 57.3 | 58.424 | 104.028 | 103.735 | 19.67 |
| 9606 | 44.278 | 43.955 | 57.965 | 57.532 | 100.17 | 99.547 | 15.78 |
| 9650 | 48.847 | 48.092 | 72.385 | 72.126 | 117.193 | 116.121 | 15.813 |
| 9700 | 55.72 | 53.774 | 73.898 | 75.416 | 129.579 | 128.504 | 23.077 |
| 9702 | 47.309 | 46.961 | 65.595 | 64.774 | 111.63 | 110.279 | 19.615 |
| 9713 | 55.385 | 54.974 | 58.844 | 58.286 | 113.332 | 112.356 | 19.615 |
| 9733 | 46.071 | 45.873 | 66.56 | 66.643 | 112.488 | 112.408 | 22.919 |
| 9872 | 62.432 | 61.126 | 80.521 | 80.054 | 142.735 | 141.157 | 23.853 |
| 9873 | 44.711 | 45.115 | 56.322 | 55.508 | 100.862 | 100.308 | 19.233 |
| 9903 | 50.412 | 50.341 | 61.625 | 61.644 | 112.016 | 111.935 | 20.821 |
| 9910 | 53.749 | 53.151 | 71.714 | 71.131 | 125.341 | 124.026 | 24.643 |
| 9919 | 56.23 | 55.371 | 56.552 | 56.726 | 111.624 | 110.987 | 19.67 |
| 9938 | 56.539 | 54.658 | 82.293 | 84.004 | 136.565 | 135.323 | 26.98 |
| 9945 | 60 | 58.814 | 75.601 | 74.964 | 134.993 | 133.26 | 27.081 |

| Case ID | Lin a8 | Lin b8 | Lin a9 | Lin b9 | Lin a10 | Lin b10 | Lin a11 |
|---|---|---|---|---|---|---|---|
| 9984 | 56.203 | 55.363 | 70.392 | 69.807 | 126.013 | 124.668 | 21.54 |
| 9985 | 59.266 | 58.79 | 76.911 | 77.268 | 133.92 | 132.516 | 25.061 |
| 9988 | 49.017 | 48.348 | 63.585 | 62.439 | 111.963 | 110.337 | 20.393 |
| 10047 | 54.225 | 54.806 | 59.103 | 59.748 | 112.723 | 112.871 | 19.452 |
| 10048 | 48.588 | 48.622 | 63.061 | 63.134 | 109.894 | 109.588 | 17.846 |
| 10050 | 56.84 | 56.707 | 73.282 | 71.899 | 128.778 | 127.263 | 23.195 |
| 10071 | 48.505 | 48.124 | 63.132 | 61.425 | 110.754 | 108.651 | 19.266 |
| 10110 | 51.796 | 51.374 | 70.115 | 70.474 | 120.923 | 120.738 | 21.013 |
| 10112 | 50.952 | 50.45 | 62.145 | 62.231 | 112.639 | 111.903 | 22.037 |
| 10133 | 48.758 | 49.585 | 63.594 | 62.326 | 111.826 | 111.685 | 17.557 |
| 10140 | 54.198 | 53.845 | 71.514 | 71.29 | 123.158 | 122.756 | 22.207 |
| 10141 | 51.229 | 52.342 | 68.827 | 68.193 | 119.143 | 119.629 | 20.662 |
| 10174 | 49.742 | 49.107 | 51.811 | 52.212 | 100.638 | 100.471 | 13.852 |
| 10176 | 52.047 | 51.567 | 66.734 | 67.08 | 117.217 | 116.627 | 19.901 |
| 10233 | 53.602 | 53.121 | 69.954 | 69.485 | 123.215 | 122.313 | 24.768 |
| 10254 | 43.63 | 43.21 | 58.422 | 58.786 | 101.385 | 101.267 | 19.849 |
| 10282 | 50.714 | 51.243 | 65.04 | 64.602 | 115.445 | 115.671 | 21.122 |
| 10284 | 53.615 | 53.478 | 68.06 | 68.13 | 121.042 | 120.999 | 18.358 |
| 10315 | 51.843 | 52.16 | 67.134 | 66.622 | 118.842 | 118.776 | 19.847 |
| 10344 | 52.685 | 53.061 | 65.774 | 65.144 | 117.758 | 117.669 | 20.237 |
| 10346 | 58.59 | 58.297 | 74.243 | 73.568 | 131.932 | 131.405 | 23.504 |
| 10354 | 52.342 | 52.474 | 75.314 | 75.458 | 126.966 | 126.749 | 21.424 |
| 10369 | 57.415 | 57.087 | 62.7 | 61.726 | 118.214 | 117.074 | 18.609 |
| 10392 | 55.363 | 55.371 | 69.429 | 68.472 | 123.57 | 122.666 | 23.693 |
| 10399 | 49.563 | 49.542 | 69.608 | 70.122 | 119.147 | 119.515 | 20.282 |
| 10423 | 55.485 | 54.689 | 75.871 | 75.668 | 130.537 | 129.818 | 23.348 |
| 10445 | 51.046 | 51.043 | 68.474 | 69.485 | 119.506 | 120.172 | 22.037 |
| 10447 | 50.466 | 50.45 | 68.993 | 69.239 | 117.261 | 116.746 | 20.712 |
| 10485 | 50.308 | 49.962 | 61.322 | 60.61 | 111.081 | 110.146 | 20.662 |
| 10491 | 50.069 | 50.403 | 56.832 | 56.956 | 104.956 | 105.107 | 19.085 |
| 10495 | 53.615 | 53.532 | 63.889 | 64.702 | 117.07 | 117.673 | 20.958 |
| 10515 | 52.55 | 52.505 | 60.491 | 60.343 | 112.425 | 112.342 | 19.954 |
| 10517 | 55.406 | 55.787 | 59.182 | 58.808 | 114.261 | 114.261 | 18.723 |
| 10549 | 46.569 | 46.573 | 59.674 | 59.926 | 105.747 | 105.935 | 17.596 |
| 10553 | 48.095 | 47.732 | 70.101 | 69.288 | 117.061 | 116.217 | 22.527 |
| 10554 | 49.362 | 49.204 | 68.793 | 67.45 | 117.502 | 116.301 | 22.908 |
| 10555 | 52.319 | 52.372 | 59.249 | 58.507 | 111.011 | 110.425 | 19.643 |
| 10569 | 50.123 | 50.031 | 60.233 | 60.284 | 109.53 | 108.903 | 18.055 |
| 10570 | 51.265 | 51.991 | 61.917 | 61.168 | 112.176 | 112.452 | 19.086 |
| 10571 | 58.371 | 58.474 | 77.926 | 77.145 | 134.178 | 133.577 | 23.4 |
| 10572 | 45.895 | 45.835 | 64.862 | 64.774 | 109.836 | 109.673 | 20.611 |

| Case ID | Lin a8 | Lin b8 | Lin a9 | Lin b9 | Lin a10 | Lin b10 | Lin a11 |
|---|---|---|---|---|---|---|---|
| 10573 | 48.877 | 49.238 | 70.36 | 69.972 | 119.118 | 118.814 | 25.969 |
| 10574 | 54.587 | 55.437 | 67.435 | 66.55 | 121.167 | 121.438 | 20.994 |
| 10575 | 50.403 | 49.619 | 70.116 | 71.864 | 118.476 | 119.146 | 20.662 |
| 10576 | 49.24 | 49.626 | 68.398 | 67.944 | 116.266 | 116.266 | 20.992 |
| 10586 | 51.922 | 51.912 | 68.703 | 68.543 | 119.949 | 119.614 | 21.025 |
| 10589 | 51.929 | 51.916 | 79.957 | 80.023 | 130.289 | 130.349 | 23.693 |
| 10595 | 50.021 | 49.618 | 60.195 | 60.421 | 109.586 | 109.47 | 18.404 |
| 10596 | 52.474 | 52.584 | 59.569 | 59.724 | 110.97 | 111.477 | 18.435 |
| 10626 | 50.767 | 51.158 | 63.302 | 62.888 | 113.155 | 113.059 | 23.709 |
| 10627 | 49.383 | 50.069 | 61.86 | 61.289 | 111.052 | 111.011 | 22.261 |
| 10629 | 49.661 | 49.742 | 72.341 | 71.392 | 119.309 | 118.561 | 21.535 |
| 10631 | 47.343 | 48.095 | 74.203 | 73.93 | 120.351 | 120.668 | 24.11 |
| 10638 | 54.2 | 54.2 | 68.875 | 68.947 | 122.64 | 122.483 | 20.231 |
| 10639 | 56.489 | 55.836 | 69.297 | 69.299 | 122.387 | 121.791 | 21.066 |
| 10640 | 48.646 | 49.003 | 68.875 | 68.229 | 116.928 | 116.554 | 21.764 |
| 10642 | 50.687 | 51.478 | 70.211 | 69.305 | 120.29 | 120.224 | 19.466 |
| 10643 | 59.577 | 60.688 | 78.267 | 77.699 | 136.922 | 137.654 | 20.907 |
| 10645 | 53.666 | 53.211 | 69.299 | 68.715 | 121.51 | 120.795 | 23.214 |
| 10646 | 52.759 | 52.616 | 73.386 | 74.025 | 125.657 | 126.066 | 22.549 |
| 10647 | 49.277 | 50.72 | 66.233 | 66.716 | 115.126 | 117.047 | 19.466 |
| 10666 | 59.345 | 60.044 | 73.317 | 74.113 | 131.923 | 133.161 | 23.68 |
| 10667 | 58.016 | 57.634 | 69.224 | 69.439 | 126.982 | 126.896 | 24.471 |
| 10670 | 59.765 | 59.478 | 65.024 | 64.586 | 124.678 | 123.841 | 21.392 |
| 10671 | 58.342 | 57.991 | 72.545 | 73.804 | 130.226 | 131.349 | 26.811 |
| 10713 | 49.619 | 50.001 | 68.715 | 67.31 | 116.495 | 115.995 | 22.566 |
| 10714 | 50.385 | 52.297 | 71.268 | 69.174 | 119.905 | 119.782 | 25.299 |
| 10716 | 52.684 | 52.474 | 66.155 | 66.674 | 117.754 | 117.964 | 22.672 |
| 10720 | 59.828 | 59.302 | 63.987 | 64.332 | 123.289 | 123.088 | 17.998 |
| 10732 | 50.794 | 50.832 | 55.974 | 55.788 | 105.814 | 105.704 | 19.779 |
| 10733 | 50.289 | 51.707 | 67.003 | 68.215 | 117.117 | 119.516 | 22.155 |
| 10734 | 54.727 | 54.638 | 74.904 | 75.481 | 128.907 | 129.457 | 22.672 |
| 10736 | 49.542 | 49.443 | 67.199 | 67.812 | 116.203 | 116.528 | 18.739 |
| 10737 | 51.287 | 51.964 | 70.101 | 70.506 | 121.149 | 122.085 | 26.059 |
| 10740 | 54.237 | 53.845 | 63.04 | 62.771 | 116.912 | 116.33 | 23.194 |
| 10741 | 51.411 | 51.548 | 57.543 | 58.002 | 108.923 | 109.478 | 21.284 |
| 10788 | 48.869 | 50.103 | 65.734 | 65.233 | 114.125 | 114.459 | 19.925 |
| 10791 | 58.988 | 59.014 | 63.094 | 63.048 | 120.968 | 120.862 | 23.748 |
| 10793 | 49.17 | 48.961 | 61.351 | 61.724 | 110.377 | 110.382 | 19.084 |
| 10794 | 52.205 | 53.592 | 69.798 | 69.656 | 121.678 | 122.694 | 24.053 |
| 10833 | 57.645 | 56.495 | 64.873 | 66.497 | 120.403 | 120.278 | 21.066 |
| 10837 | 53.857 | 54.166 | 64.397 | 64.652 | 118.148 | 118.625 | 21.382 |

| Case ID | Lin a8 | Lin b8 | Lin a9 | Lin b9 | Lin a10 | Lin b10 | Lin a11 |
|---|---|---|---|---|---|---|---|
| 10839 | 54.545 | 54.134 | 56.813 | 56.865 | 110.599 | 110.063 | 19.581 |
| 10840 | 48.926 | 49.268 | 63.097 | 62.822 | 111.726 | 111.811 | 22.232 |
| 10877 | 51.207 | 51.246 | 72.797 | 73.043 | 122.85 | 123.008 | 20.712 |
| 10878 | 57.398 | 57.694 | 68.875 | 69.325 | 125.537 | 126.072 | 20.644 |
| 10879 | 53.093 | 52.788 | 68.853 | 69.402 | 120.725 | 121.149 | 20.611 |
| 10882 | 46.206 | 47.336 | 58.212 | 56.882 | 104.034 | 103.782 | 19.104 |
| 10919 | 50.385 | 50.45 | 58.25 | 58.713 | 107.065 | 106.669 | 18.114 |
| 10959 | 53.156 | 53.134 | 68.024 | 66.858 | 120.289 | 118.915 | 22.722 |
| 10960 | 49.891 | 49.487 | 59.797 | 59.88 | 109.109 | 108.843 | 20.254 |
| 10962 | 52.106 | 52.408 | 67.082 | 67.585 | 118.669 | 119.171 | 24.904 |
| 10969 | 47.38 | 47.799 | 61.097 | 59.829 | 108.112 | 107.171 | 18.498 |
| 10989 | 58.646 | 57.694 | 69.227 | 69.78 | 125.837 | 125.12 | 19.976 |
| 10998 | 53.481 | 53.486 | 72.119 | 72.253 | 123.756 | 123.028 | 22.694 |
| 11004 | 49.616 | 49.661 | 63.811 | 62.971 | 112.558 | 111.76 | 17.752 |
| 11048 | 55.003 | 55.732 | 64.361 | 63.374 | 118.706 | 118.084 | 22.7 |
| 11075 | 48.077 | 47.724 | 69.76 | 69.532 | 116.197 | 115.256 | 19.624 |
| 11077 | 50.03 | 49.622 | 72.454 | 71.421 | 121.739 | 120.467 | 23.463 |
| 11080 | 58.182 | 58.883 | 72.623 | 71.29 | 129.395 | 128.002 | 23.478 |
| 11108 | 52.004 | 52.047 | 68.391 | 67.88 | 118.39 | 117.678 | 18.098 |
| 11110 | 46.924 | 47.343 | 70.001 | 69.903 | 115.12 | 114.263 | 20.008 |
| 11146 | 53.866 | 54.237 | 68.936 | 67.695 | 121.95 | 120.327 | 20.82 |
| 11336 | 47.693 | 47.711 | 72.978 | 72.215 | 117.867 | 117.366 | 20.387 |
| 11440 | 51.559 | 50.383 | 63.806 | 63.446 | 114.55 | 112.982 | 18.866 |

## Appendix 6(d)

| Case ID | Lin b11 | Lin a12 | Lin b12 | Lin a13 | Lin b13 | Lin a14 | Lin b14 |
|---|---|---|---|---|---|---|---|
| 1782 | 24.919 | 53.167 | 53.251 | 56.281 | 56.442 | 47.919 | 47.763 |
| 2476 | 23.729 | 53.284 | 53.364 | 56.808 | 56.13 | 45.719 | 44.451 |
| 4005 | 21.406 | 53.307 | 54.575 | 52.607 | 52.884 | 45.495 | 45.54 |
| 4381 | 18.404 | 50.245 | 52.507 | 46.177 | 45.062 | 37.748 | 36.278 |
| 4703 | 21.758 | 50.756 | 52.279 | 56.835 | 55.946 | 41.419 | 40.501 |
| 5105 | 20.662 | 52.707 | 53.168 | 57.544 | 56.193 | 44.338 | 43.471 |
| 5748 | 26.342 | 47.39 | 48.143 | 58.355 | 57.784 | 46.304 | 45.829 |
| 6229 | 26.724 | 49.433 | 51.262 | 51.926 | 51.175 | 39.258 | 37.842 |
| 6429 | 22.903 | 53.101 | 51.391 | 60.001 | 58.415 | 48.85 | 48.877 |
| 6796 | 21.376 | 54.294 | 55.525 | 62.81 | 61.027 | 51.35 | 49.168 |
| 7702 | 17.977 | 48.926 | 48.882 | 44.293 | 43.155 | 37.309 | 36.66 |
| 7703 | 19.12 | 54.522 | 53.547 | 48.952 | 48.53 | 42.888 | 42.131 |
| 7747 | 19.485 | 51.78 | 54.03 | 56.55 | 55.304 | 45.338 | 44.74 |
| 7749 | 19.847 | 54.496 | 53.929 | 51.639 | 51.099 | 40.107 | 39.526 |
| 7767 | 23.882 | 54.727 | 59.887 | 57.932 | 57.499 | 46.117 | 45.454 |
| 7793 | 20.583 | 51.7 | 52.615 | 51.552 | 52.311 | 44.308 | 43.955 |
| 7856 | 21.011 | 50.928 | 50.907 | 57.396 | 56.931 | 45.575 | 45.626 |
| 7907 | 20.583 | 45.821 | 46.009 | 46.816 | 46.391 | 40.655 | 39.496 |
| 7939 | 18.739 | 53.284 | 53.572 | 55.933 | 55.531 | 45.146 | 44.569 |
| 7947 | 26.743 | 52.314 | 53.614 | 69.499 | 68.142 | 53.364 | 52.119 |
| 7963 | 22.527 | 49.939 | 49.49 | 57.207 | 57.121 | 47.624 | 49.482 |
| 7971 | 20.263 | 48.529 | 49.017 | 58.339 | 56.282 | 45.211 | 43.903 |
| 8014 | 17.579 | 46.421 | 50.445 | 46.937 | 46.339 | 38.532 | 38.737 |
| 8046 | 22.992 | 49.818 | 50.343 | 57.423 | 56.923 | 44.778 | 43.274 |
| 8063 | 19.193 | 55.511 | 55.41 | 53.115 | 54.351 | 41.182 | 40.838 |
| 8081 | 19.847 | 52.623 | 52.323 | 55.839 | 54.145 | 45.216 | 44.836 |
| 8089 | 20.305 | 49.899 | 50.712 | 56.55 | 55.716 | 41.604 | 40.416 |
| 8090 | 19.474 | 51.968 | 50.155 | 55.402 | 54.198 | 40.94 | 40.904 |
| 8121 | 19.266 | 52.545 | 53.38 | 53.777 | 52.816 | 43.593 | 43.693 |
| 8122 | 20.802 | 53.595 | 53.675 | 56.533 | 57.208 | 49.378 | 48.813 |
| 8163 | 21.226 | 52.526 | 52.063 | 54.813 | 52.9 | 41.416 | 42.152 |
| 8244 | 22.813 | 46.364 | 47.836 | 53.878 | 53.398 | 39.237 | 38.4 |
| 8254 | 19.722 | 52.439 | 52.58 | 56.161 | 57.719 | 41.564 | 41.564 |
| 8255 | 17.428 | 56.465 | 56.31 | 53.639 | 53.558 | 42.149 | 41.329 |
| 8258 | 18.867 | 50.589 | 54.821 | 50.143 | 54.002 | 39.722 | 39.362 |
| 8261 | 22.694 | 53.946 | 54.054 | 60.404 | 62.388 | 48.287 | 49.054 |
| 8288 | 23.875 | 48.979 | 52.267 | 60.542 | 62.172 | 45.925 | 47.186 |
| 8293 | 22.325 | 53.786 | 55.025 | 59.623 | 64.708 | 50.59 | 51.909 |
| 8294 | 18.079 | 48.311 | 48.88 | 54.989 | 55.634 | 41.224 | 42.634 |

| Case ID | Lin b11 | Lin a12 | Lin b12 | Lin a13 | Lin b13 | Lin a14 | Lin b14 |
|---|---|---|---|---|---|---|---|
| 9064 | 20.231 | 50.736 | 52.129 | 50.001 | 48.858 | 42.708 | 41.231 |
| 9087 | 20.231 | 50.706 | 50.82 | 57.319 | 56.381 | 42.217 | 40.348 |
| 9088 | 22.155 | 53.675 | 52.801 | 54.132 | 54.074 | 43.363 | 41.804 |
| 9092 | 20.231 | 54.239 | 53.647 | 62.53 | 62.694 | 48.251 | 48.199 |
| 9093 | 21.535 | 52.786 | 53.396 | 56.6 | 56.144 | 45.904 | 45.861 |
| 9124 | 17.645 | 53.025 | 52.468 | 51.658 | 50.484 | 40.209 | 37.628 |
| 9125 | 18.711 | 53.476 | 52.885 | 56.139 | 56.821 | 47.323 | 46.552 |
| 9128 | 18.759 | 50.601 | 52.069 | 51.072 | 49.051 | 38.132 | 37.079 |
| 9129 | 18.323 | 52.943 | 52.602 | 50.794 | 49.138 | 41.948 | 40.285 |
| 9161 | 21.011 | 51.493 | 51.854 | 56.501 | 55.704 | 44.226 | 42.345 |
| 9162 | 22.568 | 52.887 | 51.72 | 58.611 | 58.172 | 53.19 | 52.369 |
| 9163 | 22.992 | 55.554 | 57.797 | 55.846 | 56.278 | 45.077 | 46.391 |
| 9164 | 23.545 | 49.915 | 49.029 | 52.308 | 51.912 | 41.548 | 40.849 |
| 9202 | 24.825 | 55.347 | 58.981 | 77.935 | 76.56 | 65.646 | 65.148 |
| 9244 | 16.097 | 49.065 | 48.25 | 45.243 | 44.901 | 34.41 | 33.771 |
| 9247 | 19.52 | 52.986 | 54.573 | 58.954 | 56.854 | 49.907 | 47.048 |
| 9273 | 19.21 | 54.684 | 55.918 | 54.432 | 52.146 | 41.686 | 39.876 |
| 9274 | 25.198 | 56.033 | 58.173 | 56.998 | 56.199 | 45.845 | 44.337 |
| 9284 | 19.953 | 51.037 | 53.679 | 51.487 | 51.446 | 40.088 | 39.664 |
| 9309 | 22.708 | 59.447 | 57.943 | 60.23 | 61.187 | 47.894 | 47.481 |
| 9340 | 19.985 | 50.449 | 53.118 | 55.862 | 55.517 | 48.747 | 48.861 |
| 9344 | 21.011 | 52.153 | 52.197 | 57.551 | 56.744 | 46.066 | 44.973 |
| 9347 | 19.985 | 53.333 | 53.125 | 56.545 | 55.737 | 41.96 | 41.64 |
| 9382 | 25.898 | 55.649 | 55.919 | 69.793 | 70.385 | 60.614 | 59.098 |
| 9411 | 24.49 | 57.685 | 57.034 | 64.332 | 64.415 | 52.185 | 51.665 |
| 9467 | 19.164 | 54.729 | 55.082 | 52.659 | 51.796 | 42.935 | 41.113 |
| 9479 | 19.164 | 50.12 | 51.342 | 49.122 | 48.087 | 37.691 | 38.501 |
| 9559 | 19.501 | 52.202 | 52.904 | 53.661 | 53.063 | 48.168 | 47.706 |
| 9606 | 15.27 | 48.982 | 48.971 | 44.226 | 43.146 | 34.131 | 33.76 |
| 9650 | 17.56 | 51.776 | 48.34 | 40.77 | 40.841 | 35.389 | 34.738 |
| 9700 | 23.666 | 46.192 | 50.882 | 61.165 | 59.553 | 53.142 | 51.175 |
| 9702 | 20.231 | 50.411 | 51.161 | 49.894 | 48.791 | 39.582 | 38.192 |
| 9713 | 18.702 | 56.332 | 54.208 | 55.251 | 55.541 | 45.342 | 44.521 |
| 9733 | 23.087 | 45.249 | 44.013 | 54.243 | 52.679 | 46.553 | 46.198 |
| 9872 | 23.693 | 49.846 | 52.484 | 63.499 | 64.511 | 53.619 | 52.128 |
| 9873 | 18.711 | 50.074 | 50.907 | 48.747 | 48.758 | 41.187 | 40.348 |
| 9903 | 20.662 | 56.309 | 57.221 | 60.391 | 58.47 | 48.134 | 47.418 |
| 9910 | 24.048 | 50.37 | 52.129 | 65.129 | 64.064 | 52.108 | 51.035 |
| 9919 | 18.723 | 55.448 | 54.24 | 56.614 | 56.564 | 45.115 | 45.153 |
| 9938 | 26.743 | 59.312 | 60.681 | 56.539 | 57.312 | 39.232 | 39.696 |
| 9945 | 26.569 | 61.528 | 61.303 | 72.036 | 70.511 | 57.609 | 55.531 |

| Case ID | Lin b11 | Lin a12 | Lin b12 | Lin a13 | Lin b13 | Lin a14 | Lin b14 |
|---|---|---|---|---|---|---|---|
| 9984 | 20.992 | 55.571 | 55.058 | 62.352 | 61.226 | 46.597 | 46.697 |
| 9985 | 24.49 | 47.334 | 48.199 | 59.687 | 58.851 | 44.662 | 43.928 |
| 9988 | 19.849 | 51.599 | 50.64 | 47.847 | 47.554 | 38.887 | 38.726 |
| 10047 | 19.265 | 50.601 | 54.411 | 54.281 | 53.931 | 43.964 | 42.944 |
| 10048 | 19.307 | 54.017 | 55.157 | 50.629 | 49.432 | 42.794 | 41.676 |
| 10050 | 23.844 | 59.468 | 58.297 | 54.89 | 53.177 | 44.274 | 41.486 |
| 10071 | 18.739 | 50.641 | 51.29 | 54.868 | 53.894 | 42.981 | 41.676 |
| 10110 | 21.388 | 53.875 | 54.065 | 59.541 | 59.888 | 47.559 | 46.744 |
| 10112 | 22.568 | 52.154 | 53.523 | 57.398 | 57.039 | 48.56 | 48.142 |
| 10133 | 17.198 | 48.164 | 46.52 | 50.598 | 50.928 | 37.116 | 36.67 |
| 10140 | 21.502 | 53.929 | 53.789 | 53.64 | 52.499 | 42.035 | 42.05 |
| 10141 | 20.619 | 56.361 | 53.918 | 65.288 | 65.222 | 53.955 | 53.458 |
| 10174 | 14.198 | 54.098 | 54.646 | 43.827 | 43.284 | 33.567 | 32.426 |
| 10176 | 20.644 | 54.499 | 54.629 | 51.548 | 49.489 | 41.256 | 39.987 |
| 10233 | 24.818 | 53.959 | 54.081 | 58.779 | 58.051 | 50.794 | 50.817 |
| 10254 | 20.229 | 45.877 | 45.449 | 47.401 | 47.02 | 36.355 | 35.192 |
| 10282 | 20.778 | 50.925 | 51.757 | 59.924 | 58.785 | 47.742 | 45.435 |
| 10284 | 19.573 | 54.755 | 55.602 | 52.759 | 52.554 | 42.567 | 41.556 |
| 10315 | 20.237 | 49.709 | 48.059 | 58.485 | 57.694 | 44.734 | 44.322 |
| 10344 | 20.994 | 53.711 | 52.339 | 50.246 | 50.069 | 44.362 | 42.973 |
| 10346 | 23.504 | 53.212 | 51.395 | 58.782 | 56.882 | 45.805 | 43.909 |
| 10354 | 22.612 | 53.269 | 51.95 | 54.583 | 55.35 | 42.375 | 43.897 |
| 10369 | 18.654 | 53.848 | 52.855 | 54.238 | 53.066 | 41.163 | 41.226 |
| 10392 | 24.062 | 56.529 | 56.641 | 58.297 | 57.376 | 46.152 | 45.628 |
| 10399 | 21.092 | 48.98 | 50.442 | 51.148 | 51.929 | 39.699 | 40.086 |
| 10423 | 23.372 | 58.347 | 56.976 | 62.591 | 62.24 | 49.403 | 49.047 |
| 10445 | 22.888 | 49.653 | 53.212 | 50.383 | 50.389 | 45.115 | 45.153 |
| 10447 | 20.662 | 50.551 | 50.243 | 54.199 | 53.066 | 42.752 | 40.844 |
| 10485 | 20.237 | 51.279 | 50.902 | 54.712 | 53.592 | 48.032 | 47.346 |
| 10491 | 18.279 | 55.03 | 55.177 | 51.61 | 50.484 | 41.686 | 40.183 |
| 10495 | 21.66 | 52.658 | 52.169 | 54.729 | 55.051 | 44.171 | 44.446 |
| 10515 | 19.833 | 56.978 | 57.333 | 54.218 | 56.169 | 43.131 | 42.749 |
| 10517 | 18.723 | 51.096 | 51.854 | 56.474 | 56.13 | 44.74 | 43.984 |
| 10549 | 20.229 | 52.697 | 52.435 | 51.566 | 51.994 | 45.377 | 44.836 |
| 10553 | 23.68 | 53.119 | 52.191 | 58.228 | 57.17 | 50.49 | 48.938 |
| 10554 | 23.312 | 48.03 | 47.947 | 58.433 | 57.634 | 47.038 | 46.588 |
| 10555 | 19.643 | 55.47 | 55.019 | 56.216 | 55.774 | 49.078 | 49.407 |
| 10569 | 18.848 | 48.788 | 49.971 | 49.292 | 48.495 | 40.924 | 40.484 |
| 10570 | 19.086 | 50.285 | 49.601 | 56.229 | 55.961 | 43.325 | 43.079 |
| 10571 | 23.02 | 58.833 | 58.366 | 65.984 | 64.278 | 47.87 | 48.049 |
| 10572 | 20.994 | 49.62 | 50.765 | 52.422 | 51.22 | 44.396 | 43.216 |

| Case ID | Lin b11 | Lin a12 | Lin b12 | Lin a13 | Lin b13 | Lin a14 | Lin b14 |
|---|---|---|---|---|---|---|---|
| 10573 | 25.995 | 54.776 | 56.104 | 63.335 | 63.248 | 57.14 | 57.836 |
| 10574 | 21.773 | 59.939 | 58.264 | 66.796 | 66.109 | 52.673 | 51.547 |
| 10575 | 21.406 | 57.086 | 57.985 | 52.29 | 51.912 | 44.31 | 43.146 |
| 10576 | 20.611 | 55.75 | 55.578 | 55.726 | 54.58 | 45.466 | 44.31 |
| 10586 | 20.248 | 54.867 | 56.713 | 56.544 | 56.203 | 44.074 | 43.984 |
| 10589 | 23.729 | 54.415 | 53.451 | 56.997 | 56.597 | 44.337 | 44.734 |
| 10595 | 19.164 | 53.291 | 53.399 | 54.675 | 54.249 | 42.944 | 42.973 |
| 10596 | 18.435 | 54.689 | 53.577 | 51.353 | 51.47 | 39.783 | 39.298 |
| 10626 | 23.752 | 53.929 | 54.696 | 56.448 | 55.945 | 45.908 | 45.457 |
| 10627 | 21.881 | 56.038 | 56.386 | 53.681 | 53.933 | 43.955 | 43.096 |
| 10629 | 20.817 | 52.697 | 56.523 | 51.528 | 51.146 | 38.168 | 38.932 |
| 10631 | 23.709 | 50.832 | 52.123 | 60.732 | 60.732 | 47.418 | 47.057 |
| 10638 | 19.468 | 52.671 | 53.118 | 55.186 | 54.924 | 45.251 | 44.208 |
| 10639 | 21.392 | 60.642 | 63.662 | 59.167 | 59.186 | 46.187 | 46.229 |
| 10640 | 23.372 | 54.629 | 55.189 | 59.828 | 60.51 | 47.653 | 47.999 |
| 10642 | 21.025 | 53.419 | 53.929 | 53.868 | 53.845 | 39.401 | 38.621 |
| 10643 | 20.817 | 52.16 | 51.505 | 62.771 | 62.58 | 47.241 | 46.807 |
| 10645 | 23.923 | 55.976 | 54.294 | 58.4 | 57.279 | 50.055 | 49.383 |
| 10646 | 22.549 | 50.995 | 51.21 | 59.577 | 59.629 | 43.146 | 42.403 |
| 10647 | 20.229 | 47.079 | 49.715 | 44.699 | 45.724 | 35.647 | 35.129 |
| 10666 | 24.048 | 55.341 | 57.233 | 59.509 | 60.129 | 54.545 | 52.146 |
| 10667 | 25.274 | 47.134 | 48.257 | 59.61 | 60.025 | 45.495 | 45.538 |
| 10670 | 21.787 | 51.515 | 51.865 | 55.103 | 54.952 | 46.252 | 44.836 |
| 10671 | 27.786 | 54.013 | 54.097 | 62.229 | 62.816 | 53.995 | 53.464 |
| 10713 | 21.826 | 55.44 | 54.977 | 52.616 | 52.356 | 44.74 | 44.243 |
| 10714 | 25.099 | 56.287 | 57.23 | 60.208 | 58.281 | 49.962 | 48.758 |
| 10716 | 21.424 | 54.901 | 55.298 | 54.689 | 53.446 | 44.281 | 43.32 |
| 10720 | 18.358 | 56.942 | 56.908 | 60.331 | 60.34 | 49.688 | 49.342 |
| 10732 | 19.833 | 53.395 | 53.395 | 53.64 | 52.237 | 43.486 | 43.108 |
| 10733 | 22.155 | 43.455 | 51.658 | 54.02 | 52.831 | 43.071 | 42.213 |
| 10734 | 22.791 | 53.8 | 53.383 | 59.248 | 59.935 | 44.772 | 46.217 |
| 10736 | 19.867 | 48.476 | 49.754 | 52.119 | 51.964 | 41.935 | 41.299 |
| 10737 | 25.708 | 58.102 | 60.284 | 63.413 | 62.258 | 50.504 | 48.911 |
| 10740 | 22.754 | 55.707 | 55.979 | 60.561 | 60.237 | 50.034 | 49.776 |
| 10741 | 21.195 | 54.789 | 57.516 | 54.272 | 54.436 | 46.747 | 46.433 |
| 10788 | 19.164 | 51.262 | 54.134 | 53.021 | 53.173 | 41.278 | 41.089 |
| 10791 | 24.181 | 57.492 | 59.465 | 60.588 | 60.51 | 51.246 | 50.376 |
| 10793 | 19.867 | 47.973 | 50.146 | 50.805 | 52.008 | 40.51 | 40.924 |
| 10794 | 24.837 | 54.808 | 57.512 | 62.516 | 62.925 | 51.478 | 51.133 |
| 10833 | 21.043 | 55.483 | 54.801 | 50.069 | 49.688 | 37.815 | 37.052 |
| 10837 | 21.392 | 51.477 | 52.914 | 56.854 | 55.751 | 42.809 | 41.343 |

| Case ID | Lin b11 | Lin a12 | Lin b12 | Lin a13 | Lin b13 | Lin a14 | Lin b14 |
|---|---|---|---|---|---|---|---|
| 10839 | 19.085 | 53.731 | 54.168 | 50.763 | 51.158 | 44.337 | 43.99 |
| 10840 | 18.784 | 51.096 | 52.129 | 54.527 | 55.328 | 44.827 | 44.705 |
| 10877 | 19.12 | 51.117 | 52.229 | 53.464 | 53.436 | 42.812 | 43.165 |
| 10878 | 21.826 | 57.199 | 58.937 | 53.723 | 51.624 | 48.142 | 47.181 |
| 10879 | 19.849 | 56.946 | 56.378 | 53.189 | 53.64 | 46.173 | 45.873 |
| 10882 | 19.466 | 46.652 | 46.093 | 55.029 | 53.787 | 42.616 | 41.438 |
| 10919 | 18.759 | 50.378 | 52.904 | 52.513 | 52.305 | 43.93 | 42.809 |
| 10959 | 22.587 | 48.407 | 48.752 | 57.068 | 59.282 | 47.482 | 49.787 |
| 10960 | 19.227 | 51.535 | 52.155 | 58.872 | 56.931 | 48.203 | 46.744 |
| 10962 | 24.392 | 55.36 | 56.683 | 60.664 | 59.394 | 49.955 | 48.446 |
| 10969 | 17.977 | 49.711 | 50.7 | 51.085 | 49.962 | 42.548 | 41.299 |
| 10989 | 20.483 | 49.083 | 53.833 | 43.855 | 43.134 | 33.088 | 32.444 |
| 10998 | 22.139 | 50.863 | 53.022 | 60.057 | 59.268 | 45.963 | 45.959 |
| 11004 | 18.323 | 50.935 | 51.21 | 49.77 | 47.554 | 39.57 | 38.229 |
| 11048 | 22.137 | 52.622 | 54.492 | 60.093 | 59.541 | 49.14 | 48.312 |
| 11075 | 19.474 | 51.401 | 52.885 | 58.219 | 58.121 | 47.153 | 47.531 |
| 11077 | 22.903 | 56.891 | 51.794 | 62.662 | 61.54 | 50.612 | 48.446 |
| 11080 | 23.02 | 54.485 | 56.407 | 54.709 | 55.04 | 43.086 | 43.527 |
| 11108 | 17.579 | 49.237 | 50.551 | 45.271 | 44.208 | 37.758 | 37.773 |
| 11110 | 19.849 | 49.851 | 53.959 | 56.565 | 54.332 | 42.692 | 42.035 |
| 11146 | 21.773 | 51.868 | 54.885 | 59.65 | 58.851 | 41.191 | 39.064 |
| 11336 | 20.237 | 54.277 | 53.777 | 48.225 | 48.961 | 35.504 | 35.954 |
| 11440 | 18.711 | 53.461 | 54.411 | 52.873 | 52.072 | 44.695 | 44.03 |

## Appendix 6(e)

| Case ID | Lin a15 | Lin b15 | Lin a16 | Lin b16 | Lin a17 | Lin b17 | Lin a18 | Lin b18 |
|---|---|---|---|---|---|---|---|---|
| 1782 | 114.717 | 114.107 | 108.128 | 107.013 | 70.285 | 68.518 | 39.668 | 40.931 |
| 2476 | 110.031 | 110.14 | 100.856 | 100.785 | 65.073 | 65.722 | 39.298 | 39.991 |
| 4005 | 114.931 | 114.699 | 110.226 | 109.874 | 73.55 | 72.923 | 42.772 | 41.566 |
| 4381 | 99.893 | 97.266 | 92.283 | 89.838 | 64.758 | 62.945 | 37.603 | 38.011 |
| 4703 | 116.709 | 116.216 | 103.577 | 102.527 | 70.42 | 70.391 | 38.123 | 38.44 |
| 5105 | 116.461 | 115.384 | 104.671 | 103.922 | 72.307 | 72.53 | 36.828 | 36.023 |
| 5748 | 110.164 | 109.808 | 99.471 | 99.08 | 63.331 | 63.635 | 50.318 | 49.547 |
| 6229 | 119.708 | 117.934 | 109.263 | 106.766 | 78.067 | 76.779 | 44.89 | 44.92 |
| 6429 | 109.057 | 108.547 | 99.785 | 100.553 | 64.804 | 65.118 | 48.128 | 46.673 |
| 6796 | 122.931 | 121.292 | 113.723 | 112.662 | 73.989 | 75.083 | 40.643 | 40.21 |
| 7702 | 106.539 | 106.002 | 102.12 | 102.346 | 76.167 | 75.955 | 36.986 | 36.632 |
| 7703 | 102.365 | 100.245 | 97.714 | 95.422 | 63.789 | 62.215 | 43.08 | 43.496 |
| 7747 | 114.149 | 113.025 | 104.596 | 104.817 | 70.449 | 70.865 | 41.151 | 41.653 |
| 7749 | 114.893 | 114.648 | 105.171 | 104.39 | 74.024 | 73.846 | 43.795 | 42.835 |
| 7767 | 120.102 | 116.798 | 109.916 | 106.441 | 70.387 | 66.973 | 44.805 | 45.734 |
| 7793 | 107.805 | 108.377 | 102.531 | 101.846 | 68.919 | 68.518 | 40.389 | 40.888 |
| 7856 | 116.859 | 116.08 | 107.584 | 107.278 | 73.036 | 72.309 | 39.45 | 38.783 |
| 7907 | 95.118 | 96.034 | 89.539 | 89.763 | 53.788 | 56.398 | 38.682 | 39.076 |
| 7939 | 113.936 | 114.307 | 106.207 | 105.753 | 71.757 | 71.874 | 41.297 | 40.754 |
| 7947 | 132.818 | 132.84 | 119.47 | 119.598 | 79.859 | 81.329 | 43.819 | 43.378 |
| 7963 | 109.109 | 107.275 | 101.34 | 102.021 | 65.594 | 63.892 | 35.451 | 36.784 |
| 7971 | 115.339 | 114.308 | 104.109 | 103.556 | 70.352 | 71.056 | 38.717 | 39.179 |
| 8014 | 109.065 | 108.626 | 102.823 | 102.527 | 73.751 | 72.943 | 40.818 | 40.498 |
| 8046 | 112.434 | 112.036 | 101.772 | 100.723 | 65.982 | 66.307 | 37.906 | 38.204 |
| 8063 | 109.189 | 110.621 | 99.259 | 98.865 | 67.813 | 67.962 | 38.507 | 39.009 |
| 8081 | 112.152 | 111.427 | 103.708 | 104.39 | 67.938 | 69.441 | 39.076 | 39.438 |
| 8089 | 112.073 | 110.712 | 100.205 | 99.501 | 69.762 | 68.854 | 39.281 | 40.332 |
| 8090 | 111.114 | 110.206 | 99.855 | 99.685 | 68.795 | 68.92 | 38.176 | 38.675 |
| 8121 | 104.65 | 104.23 | 96.961 | 97.07 | 63.603 | 63.835 | 38.922 | 39.37 |
| 8122 | 108.336 | 110.372 | 103.477 | 103.514 | 63.95 | 64.344 | 35.927 | 36.312 |
| 8163 | 112.434 | 110.896 | 101.52 | 102.048 | 69.682 | 69.994 | 40.547 | 40.889 |
| 8244 | 103.677 | 107.69 | 90.843 | 94.748 | 58.909 | 63.779 | 36.425 | 36.174 |
| 8254 | 116.338 | 118.616 | 104.262 | 105.065 | 72.595 | 74.529 | 39.914 | 39.416 |
| 8255 | 111.473 | 111.508 | 101.993 | 101.766 | 69.141 | 70.129 | 40.793 | 40.819 |
| 8258 | 106.951 | 109.55 | 98.22 | 97.552 | 69.702 | 69.726 | 38.025 | 39.233 |
| 8261 | 117.635 | 119.398 | 108.87 | 109.325 | 74.766 | 74.597 | 42.958 | 43.234 |
| 8288 | 117.903 | 118.5 | 106.148 | 106.516 | 74.338 | 73.465 | 40.591 | 40.754 |
| 8293 | 118.751 | 122.419 | 112.283 | 113.094 | 75.912 | 75.457 | 40.097 | 40.187 |
| 8294 | 101.733 | 102.466 | 91.729 | 92.997 | 65.309 | 65.751 | 37.543 | 37.599 |

| Case ID | Lin a15 | Lin b15 | Lin a16 | Lin b16 | Lin a17 | Lin b17 | Lin a18 | Lin b18 |
|---|---|---|---|---|---|---|---|---|
| 9064 | 118.35 | 115.216 | 113.265 | 110.186 | 84.596 | 82.42 | 40.214 | 40.137 |
| 9087 | 115.542 | 113.791 | 102.409 | 100.134 | 69.994 | 68.518 | 38.99 | 39.214 |
| 9088 | 115.202 | 113.947 | 106.031 | 103.237 | 71.706 | 70.582 | 45.96 | 46.187 |
| 9092 | 126.932 | 124.337 | 114.635 | 112.238 | 78.119 | 76.327 | 40.496 | 41.093 |
| 9093 | 120.022 | 119.54 | 111.693 | 111.236 | 76.886 | 77.153 | 36.904 | 36.355 |
| 9124 | 102.991 | 101.498 | 93.907 | 91.606 | 63.239 | 63.425 | 37.863 | 38.102 |
| 9125 | 111.35 | 110.794 | 104.553 | 102.851 | 71.724 | 70.565 | 37.931 | 37.984 |
| 9128 | 109.24 | 108.566 | 97.043 | 97.822 | 69.86 | 71.556 | 39.212 | 38.783 |
| 9129 | 104.543 | 103.919 | 97.474 | 96.459 | 67.203 | 67.977 | 41.168 | 41.047 |
| 9161 | 116.437 | 116.216 | 106.323 | 105.006 | 71.65 | 71.268 | 41.11 | 40.622 |
| 9162 | 113.339 | 113.532 | 109.99 | 109.796 | 69.377 | 70.319 | 38.395 | 38.504 |
| 9163 | 114.632 | 113.813 | 105.853 | 105.989 | 73.801 | 72.449 | 45.579 | 44.937 |
| 9164 | 111.428 | 110.68 | 102.857 | 101.498 | 71.928 | 70.795 | 37.076 | 37.326 |
| 9202 | 135.326 | 133.175 | 125.453 | 124.14 | 80.538 | 79.368 | 43.149 | 42.336 |
| 9244 | 101.023 | 100.123 | 92.071 | 90.9 | 67.568 | 66.621 | 38.727 | 38.355 |
| 9247 | 110.58 | 111.286 | 103.497 | 103.488 | 64.267 | 67.013 | 41.143 | 40.958 |
| 9273 | 117.936 | 115.886 | 106.904 | 105.297 | 74.976 | 74.53 | 40.233 | 40.341 |
| 9274 | 119.27 | 118.206 | 110.138 | 108.244 | 77.149 | 76.785 | 39.044 | 39.162 |
| 9284 | 104.838 | 105.428 | 94.892 | 94.986 | 59.625 | 60.716 | 44.938 | 44.589 |
| 9309 | 118.17 | 117.045 | 108.155 | 106.339 | 75.208 | 73.785 | 40.505 | 41.495 |
| 9340 | 115.699 | 113.885 | 111.336 | 109.699 | 76.43 | 74.218 | 38.369 | 39.255 |
| 9344 | 121.11 | 118.156 | 111.6 | 108.296 | 74.893 | 71.809 | 41.476 | 42.519 |
| 9347 | 115.797 | 113.617 | 102.604 | 100.952 | 71.33 | 69.742 | 42.58 | 42.835 |
| 9382 | 130.186 | 128.469 | 123.076 | 120.296 | 80.519 | 78.228 | 43.755 | 43.809 |
| 9411 | 132.511 | 130.872 | 123.101 | 121.336 | 83.255 | 82.027 | 45.014 | 44.661 |
| 9467 | 114.592 | 112.851 | 106.104 | 103.881 | 71.819 | 70.921 | 35.713 | 36.355 |
| 9479 | 108.893 | 106.226 | 99.277 | 98.315 | 67.742 | 65.636 | 39.073 | 39.811 |
| 9559 | 109.923 | 108.164 | 106.584 | 105.345 | 72.189 | 70.944 | 35.671 | 36.015 |
| 9606 | 97.579 | 96.653 | 88.972 | 88.454 | 61.915 | 61.43 | 34.287 | 34.768 |
| 9650 | 93.719 | 93.6 | 89.257 | 88.509 | 59.479 | 59.425 | 43.293 | 42.976 |
| 9700 | 115.186 | 114.73 | 108.876 | 107.763 | 66.805 | 68.013 | 44.019 | 44.474 |
| 9702 | 103.655 | 102.538 | 95.534 | 94.247 | 65.859 | 65.477 | 38.923 | 38.554 |
| 9713 | 106.815 | 105.572 | 99.834 | 97.522 | 70.659 | 69.223 | 38.513 | 38.15 |
| 9733 | 110.55 | 108.844 | 105.513 | 104.584 | 72.166 | 70.951 | 39.712 | 40.601 |
| 9872 | 136.084 | 135.36 | 128.319 | 124.512 | 86.618 | 84.215 | 42.755 | 42.92 |
| 9873 | 105.459 | 105.195 | 100.153 | 98.545 | 70.856 | 70.396 | 33.26 | 33.084 |
| 9903 | 122.463 | 121.957 | 113.947 | 113.581 | 82.508 | 82.385 | 37.525 | 36.832 |
| 9910 | 123.415 | 122.946 | 113.037 | 112.022 | 75.188 | 75.349 | 39.968 | 44.259 |
| 9919 | 111.336 | 110.856 | 103.091 | 102.619 | 75.17 | 74.419 | 38.829 | 38.287 |
| 9938 | 128.503 | 127.756 | 113.644 | 111.766 | 84.79 | 82.205 | 53.221 | 53.074 |
| 9945 | 134.17 | 132.214 | 122.63 | 120.64 | 77.724 | 77.872 | 46.757 | 46.245 |

| Case ID | Lin a15 | Lin b15 | Lin a16 | Lin b16 | Lin a17 | Lin b17 | Lin a18 | Lin b18 |
|---|---|---|---|---|---|---|---|---|
| 9984 | 120.427 | 120.328 | 107.973 | 108.551 | 76.43 | 76.732 | 43.703 | 42.681 |
| 9985 | 111.414 | 110 | 97.738 | 96.265 | 61.362 | 60.499 | 44.838 | 44.773 |
| 9988 | 105.806 | 104.734 | 98.133 | 97.351 | 67.402 | 66.621 | 38.817 | 38.643 |
| 10047 | 111.713 | 110.207 | 103.921 | 101.773 | 72.099 | 70.361 | 41.006 | 41.196 |
| 10048 | 105.722 | 103.889 | 99.925 | 98.223 | 65.198 | 64.066 | 39.496 | 39.821 |
| 10050 | 119.622 | 118.287 | 109.58 | 107.246 | 71.935 | 73.009 | 39.586 | 39.068 |
| 10071 | 107.695 | 106.255 | 98.225 | 96.393 | 67.215 | 66.143 | 38.083 | 37.569 |
| 10110 | 115.262 | 115.381 | 105.43 | 104.617 | 70.274 | 69.619 | 41.597 | 42.348 |
| 10112 | 110.935 | 110.606 | 105.112 | 104.39 | 67.822 | 67.264 | 37.461 | 38.622 |
| 10133 | 108.116 | 108.219 | 96.228 | 95.255 | 69.135 | 68.826 | 39.785 | 40.31 |
| 10140 | 110.117 | 108.836 | 99.218 | 98.964 | 68.128 | 66.87 | 41.478 | 41.461 |
| 10141 | 119.489 | 117.707 | 110.663 | 109.573 | 70.865 | 70.322 | 41.143 | 41.495 |
| 10174 | 105.194 | 104.337 | 96.139 | 94.996 | 68.022 | 68.158 | 31.989 | 32.447 |
| 10176 | 110.595 | 108.043 | 101.727 | 99.912 | 67.784 | 66.387 | 40.603 | 40.6 |
| 10233 | 117.424 | 116.994 | 111.712 | 111.1 | 73.402 | 73.016 | 41.955 | 42.812 |
| 10254 | 98.603 | 98.122 | 89.931 | 88.681 | 64.396 | 64.143 | 34.523 | 35.32 |
| 10282 | 116.211 | 117.095 | 106.603 | 105.984 | 70.611 | 72.228 | 37.271 | 37.421 |
| 10284 | 119.764 | 119.54 | 111.481 | 110.447 | 76.839 | 76.84 | 41.019 | 42.049 |
| 10315 | 115.186 | 115.282 | 103.914 | 104.441 | 73.988 | 74.721 | 37.089 | 38.199 |
| 10344 | 114.887 | 114.236 | 111.413 | 109.949 | 79.858 | 79.959 | 37.496 | 37.154 |
| 10346 | 120.028 | 120.992 | 108.497 | 109.608 | 72.286 | 75.905 | 43.572 | 43.111 |
| 10354 | 119.011 | 118.822 | 109.312 | 109.792 | 76.671 | 76.394 | 44.751 | 43.59 |
| 10369 | 108.649 | 107.276 | 98.193 | 97.42 | 70.424 | 69.47 | 44.148 | 43.675 |
| 10392 | 116.129 | 114.789 | 106.245 | 105.479 | 70.481 | 71.199 | 40.264 | 39.928 |
| 10399 | 114.326 | 114.231 | 104.709 | 104.53 | 75.903 | 75.442 | 41.213 | 41.97 |
| 10423 | 127.988 | 129.695 | 117.404 | 118.673 | 76.679 | 78.534 | 44.565 | 41.784 |
| 10445 | 114.062 | 114.348 | 110.632 | 110.94 | 74.015 | 74.015 | 38.969 | 39.315 |
| 10447 | 102.832 | 100.623 | 93.491 | 90.317 | 61.796 | 60.124 | 43.985 | 44.087 |
| 10485 | 108.36 | 107.617 | 104.234 | 104.087 | 70.515 | 70.989 | 41.072 | 40.436 |
| 10491 | 104.543 | 103.791 | 96.34 | 95.381 | 66.016 | 66.315 | 36.463 | 35.8 |
| 10495 | 117.05 | 116.043 | 108.477 | 107.245 | 72.724 | 70.951 | 38.216 | 39.007 |
| 10515 | 114.277 | 115.092 | 106.121 | 105.727 | 75.567 | 75.873 | 38.099 | 37.693 |
| 10517 | 112.022 | 111.816 | 103.231 | 102.619 | 71.946 | 72.055 | 36.355 | 35.829 |
| 10549 | 107.078 | 106.564 | 103.06 | 102.109 | 69.683 | 68.342 | 35.139 | 35.933 |
| 10553 | 117.793 | 117.485 | 112.716 | 111.384 | 74.474 | 74.101 | 41.121 | 41.451 |
| 10554 | 112.189 | 110.753 | 103.323 | 102.316 | 69.161 | 69.412 | 41.072 | 41.559 |
| 10555 | 113.775 | 112.61 | 108.725 | 108.477 | 72.891 | 72.637 | 36.976 | 36.408 |
| 10569 | 102.921 | 102.281 | 96.199 | 95.682 | 65.578 | 66.033 | 38.301 | 38.162 |
| 10570 | 114.786 | 114.426 | 104.754 | 104.539 | 72.692 | 72.745 | 42.369 | 42.439 |
| 10571 | 125.136 | 124.29 | 109.613 | 110.428 | 72.591 | 73.263 | 46.159 | 45.743 |
| 10572 | 106.818 | 107.581 | 100.786 | 101.553 | 64.123 | 65.618 | 41.367 | 41.11 |

| Case ID | Lin a15 | Lin b15 | Lin a16 | Lin b16 | Lin a17 | Lin b17 | Lin a18 | Lin b18 |
|---|---|---|---|---|---|---|---|---|
| 10573 | 119.924 | 119.667 | 115.756 | 116.226 | 72.902 | 72.795 | 42.403 | 42.507 |
| 10574 | 123.295 | 122.842 | 112.867 | 112.486 | 80.894 | 81.935 | 45.549 | 46.574 |
| 10575 | 112.718 | 112.088 | 106.944 | 105.669 | 73.354 | 73.354 | 44.731 | 44.824 |
| 10576 | 112.706 | 113.04 | 105.841 | 105.841 | 74.221 | 75.05 | 43.216 | 43.381 |
| 10586 | 118.89 | 118.794 | 108.952 | 108.66 | 74.553 | 74.844 | 42.836 | 42.671 |
| 10589 | 117.061 | 116.542 | 105.492 | 105.961 | 70.164 | 70.371 | 44.441 | 45.092 |
| 10595 | 116.95 | 116.001 | 108.48 | 108.459 | 78.491 | 77.837 | 37.461 | 37.099 |
| 10596 | 108.02 | 108.131 | 98.226 | 98.145 | 67.25 | 66.68 | 36.883 | 37.357 |
| 10626 | 113.419 | 113.383 | 106.037 | 106.127 | 70.371 | 70.565 | 37.248 | 38.555 |
| 10627 | 116.033 | 116.801 | 108.959 | 109.101 | 76.299 | 77.515 | 37.239 | 36.682 |
| 10629 | 106.878 | 107.071 | 95.568 | 96.229 | 66.87 | 66.676 | 43.216 | 42.625 |
| 10631 | 120.025 | 120.341 | 109.353 | 109.574 | 74.268 | 74.759 | 45.071 | 46.306 |
| 10638 | 117.372 | 116.231 | 109.316 | 107.396 | 76.885 | 74.918 | 42.059 | 42.489 |
| 10639 | 120.245 | 119.716 | 110.054 | 110.031 | 80.182 | 80.404 | 46.261 | 46.58 |
| 10640 | 120.202 | 119.975 | 110.563 | 110.37 | 76.223 | 76.044 | 42.922 | 42.835 |
| 10642 | 113.788 | 114.908 | 102.166 | 102.89 | 72.989 | 74.626 | 40.274 | 39.804 |
| 10643 | 120.196 | 120.413 | 107.396 | 107.699 | 69.722 | 70.004 | 46.187 | 46.864 |
| 10645 | 114.267 | 114.193 | 108.391 | 109.023 | 72.454 | 73.656 | 44.116 | 43.001 |
| 10646 | 119.587 | 119.662 | 105.164 | 104.395 | 72.42 | 72.189 | 41.653 | 43.789 |
| 10647 | 103.88 | 105.481 | 96.373 | 96.769 | 66.432 | 68.021 | 38.261 | 38.529 |
| 10666 | 121.711 | 121.978 | 117.526 | 115.472 | 75.542 | 75.993 | 43.849 | 45.159 |
| 10667 | 118.092 | 119.186 | 106.762 | 107.679 | 73.867 | 75.003 | 41.819 | 40.872 |
| 10670 | 114.365 | 115.197 | 107.684 | 107.278 | 70.361 | 71.566 | 40.21 | 39.032 |
| 10671 | 121.26 | 124.208 | 115.515 | 118.266 | 77.781 | 80.939 | 43.881 | 44.462 |
| 10713 | 110.14 | 110.274 | 104.176 | 105.486 | 69.805 | 72.512 | 40.31 | 40.891 |
| 10714 | 113.802 | 113.375 | 105.423 | 105.531 | 67.319 | 69.025 | 45.019 | 45.374 |
| 10716 | 112.851 | 112.804 | 103.806 | 103.845 | 70.004 | 70.613 | 41.371 | 41.653 |
| 10720 | 117.867 | 118.273 | 109.87 | 110.289 | 75.45 | 76.386 | 39.858 | 40.154 |
| 10732 | 105.051 | 104.995 | 97.718 | 97.807 | 66.759 | 66.837 | 35.671 | 36.495 |
| 10733 | 109.955 | 110.591 | 101.273 | 102.01 | 67.672 | 69.234 | 43.572 | 44.441 |
| 10734 | 119.645 | 119.045 | 107.096 | 107.223 | 70.683 | 69.837 | 42.709 | 43.795 |
| 10736 | 104.721 | 105.807 | 96.417 | 96.769 | 62.443 | 63.672 | 41.675 | 41.852 |
| 10737 | 125.781 | 126.096 | 115.562 | 115.081 | 77.724 | 79.088 | 44.803 | 44.803 |
| 10740 | 118.279 | 119.416 | 110.563 | 112.031 | 74.389 | 75.958 | 39.811 | 39.118 |
| 10741 | 118.338 | 118.051 | 114.004 | 112.915 | 78.815 | 78.038 | 38.036 | 38.064 |
| 10788 | 111.73 | 112.486 | 102.55 | 103.096 | 71.355 | 71.614 | 39.385 | 39.214 |
| 10791 | 120.328 | 121.547 | 113.636 | 114.217 | 75.786 | 77.282 | 42.615 | 41.349 |
| 10793 | 107.218 | 108.308 | 99.076 | 99.334 | 70.865 | 71.126 | 34.739 | 36.437 |
| 10794 | 119.543 | 119.715 | 110.608 | 110.206 | 72.925 | 72.746 | 41.887 | 42.304 |
| 10833 | 109.636 | 110.759 | 98.875 | 99.665 | 70.566 | 71.724 | 40.436 | 40.753 |
| 10837 | 117.674 | 118.154 | 106.65 | 106.846 | 75.05 | 75.807 | 39.545 | 39.453 |

| Case ID | Lin a15 | Lin b15 | Lin a16 | Lin b16 | Lin a17 | Lin b17 | Lin a18 | Lin b18 |
|---|---|---|---|---|---|---|---|---|
| 10839 | 110.548 | 110.891 | 106.802 | 106.209 | 75.441 | 74.743 | 37.403 | 37.284 |
| 10840 | 113.374 | 114.432 | 104.767 | 105.765 | 69.709 | 70.556 | 38.36 | 38.839 |
| 10877 | 110.974 | 110.99 | 101.907 | 102.895 | 66.86 | 67.807 | 42.92 | 43.572 |
| 10878 | 117.896 | 116.739 | 113.827 | 113.466 | 76.052 | 75.809 | 41.559 | 41.077 |
| 10879 | 112.642 | 114.024 | 108.131 | 108.658 | 73.046 | 72.871 | 42.97 | 41.303 |
| 10882 | 103.106 | 102.845 | 93.959 | 94.026 | 63.794 | 64.403 | 34.856 | 35.033 |
| 10919 | 102.21 | 102.794 | 94.962 | 95.528 | 64.24 | 65.74 | 36.738 | 37.219 |
| 10959 | 111.31 | 112.03 | 103.44 | 104.372 | 67.767 | 67.319 | 38.976 | 40.958 |
| 10960 | 111.851 | 112.024 | 104.608 | 105.127 | 72.384 | 73.752 | 39.77 | 39.991 |
| 10962 | 119.991 | 119.878 | 111.287 | 111.245 | 73.139 | 73.815 | 42.98 | 42.041 |
| 10969 | 105.111 | 104.938 | 98.448 | 99.02 | 70.165 | 71.813 | 38.158 | 37.219 |
| 10989 | 110.561 | 109.362 | 101.09 | 100.245 | 74.836 | 74.731 | 42.503 | 43.15 |
| 10998 | 117.584 | 116.35 | 105.85 | 104.987 | 68.444 | 67.582 | 43.982 | 43.706 |
| 11004 | 106.243 | 104.629 | 97.535 | 96.591 | 66.73 | 66.68 | 38.338 | 38.768 |
| 11048 | 117.264 | 116.599 | 109.299 | 108.514 | 73.865 | 73.547 | 38.976 | 39.324 |
| 11075 | 111.819 | 112.032 | 102.892 | 103.717 | 66.467 | 67.57 | 43.201 | 44.245 |
| 11077 | 122.07 | 121.722 | 111.73 | 110.477 | 73.745 | 74.864 | 42.981 | 43.398 |
| 11080 | 111.379 | 109.575 | 103.062 | 100.886 | 73.438 | 70.708 | 43.555 | 43 |
| 11108 | 100.584 | 99.569 | 94.674 | 94.162 | 63.127 | 62.72 | 40.191 | 40.411 |
| 11110 | 109.417 | 107.636 | 99.009 | 98.364 | 69.951 | 70.323 | 44.405 | 44.463 |
| 11146 | 116.077 | 115.394 | 101.538 | 100.571 | 74.597 | 74.834 | 42.908 | 43.4 |
| 11336 | 107.164 | 107.309 | 96.885 | 96.922 | 72.825 | 72.664 | 43.018 | 43.513 |
| 11440 | 113.024 | 112.608 | 105.869 | 105.778 | 68.104 | 69.057 | 39.544 | 38.181 |

# Appendix 7

## Subjective Inter-Observer Reliability Data

## (Interpretation of Medial and Lateral Sagittal MRI Slices of TMJ)

**Key:**

| | | |
|---|---|---|
| side | Either Left or Right TMJ evaluated | |
| Ob | Observer 1 through to 4 | |
| M | Medial aspect of the joint evaluated | |
| L | Lateral aspect of the joint evaluated | |
| Subjective scoring | 1 | normal disc position |
| | 2 | slight anterior disc displacement |
| | 3 | moderate anterior disc displacement |
| | 4 | full disc displacement with reduction |
| | 5 | full disc displacement without reduction |
| | 6 | non-classifiable |

| case | side | Ob-1M | Ob-1L | Ob-2M | Ob-2L | Ob-3M | Ob-3L | Ob-4M | Ob-4L |
|---|---|---|---|---|---|---|---|---|---|
| 1 | r | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 2 | r | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 3 | l | 4 | 4 | 4 | 4 | 5 | 5 | 4 | 4 |
| 4 | r | 2 | 3 | 4 | 4 | 2 | 2 | 4 | 4 |
| 5 | l | 3 | 3 | 4 | 3 | 2 | 2 | 2 | 3 |
| 6 | r | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 7 | l | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 8 | r | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 9 | l | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 10 | l | 4 | 4 | 4 | 4 | 6 | 6 | 4 | 4 |
| 11 | r | 6 | 6 | 3 | 3 | 3 | 3 | 6 | 6 |
| 12 | r | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 13 | l | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| 14 | l | 1 | 1 | 1 | 1 | 6 | 6 | 6 | 6 |
| 15 | l | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 |
| 16 | l | 6 | 6 | 4 | 4 | 3 | 3 | 3 | 3 |
| 17 | r | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| 18 | r | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 |
| 19 | l | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 |
| 20 | l | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 |
| 21 | l | 1 | 1 | 1 | 1 | 6 | 6 | 1 | 1 |

| case | side | Ob-1M | Ob-1L | Ob-2M | Ob-2L | Ob-3M | Ob-3L | Ob-4M | Ob-4L |
|---|---|---|---|---|---|---|---|---|---|
| 22 | r | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23 | r | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 24 | r | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25 | l | 6 | 6 | 1 | 1 | 1 | 1 | 1 | 1 |
| 26 | l | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 5 |
| 27 | l | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 28 | l | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 29 | r | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| 30 | r | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| 31 | r | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 32 | r | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 33 | r | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 34 | l | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 35 | r | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 36 | r | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 4 |
| 37 | r | 2 | 2 | 4 | 1 | 2 | 2 | 1 | 1 |
| 38 | r | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 39 | l | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 40 | l | 3 | 4 | 4 | 4 | 5 | 5 | 3 | 4 |
| 41 | l | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| 42 | l | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 |
| 43 | l | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 2 |
| 44 | r | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 45 | r | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 46 | l | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 47 | r | 3 | 4 | 4 | 4 | 3 | 3 | 3 | 4 |
| 48 | r | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 |
| 49 | l | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| 50 | r | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| 51 | r | 1 | 3 | 1 | 1 | 1 | 2 | 1 | 3 |
| 52 | r | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 53 | l | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 54 | r | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 3 |
| 55 | l | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 56 | r | 1 | 1 | 1 | 1 | 6 | 6 | 3 | 3 |
| 57 | l | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 58 | l | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 59 | r | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 60 | l | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

# Appendix 8

## Objective Inter-Observer Reliability Data

## (Measurement of Disc Length and Disc Displacement on Sagittal MRI Slices of TMJ)

**Key:**

| | |
|---|---|
| Ob | Observers, numbered from 1 to 4 |
| Slice | Sagittal slice number traced by observers |
| side | Right or Left TMJ imaged |
| Disc L | Disc Length measurements (mm) |
| Disc Dis | Disc Displacement measurements (mm) |
| n | Observer did not trace slice since the slice was judges to be of poor quality and joint structures could not be defined on the image. |

**Note: 2 joints were consistently rejected by all observers since the quality of the images were too poor to trace.

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 1 | 1 | 3 | R | 9.491 | 7.410 |
| 1 | 1 | 4 | R | 5.265 | 5.663 |
| 1 | 1 | 5 | R | 5.863 | 4.591 |
| 1 | 1 | 6 | R | n | n |
| 2 | 1 | 3 | L | 6.710 | 1.235 |
| 2 | 1 | 4 | L | 6.460 | 4.540 |
| 2 | 1 | 5 | L | 8.390 | 5.665 |
| 2 | 1 | 6 | L | 4.860 | 6.470 |
| 3 | 1 | 4 | R | 9.380 | 8.530 |
| 3 | 1 | 5 | R | 8.710 | 5.465 |
| 3 | 1 | 6 | R | 6.470 | 6.485 |
| 4 | 1 | 2 | R | 9.664 | 8.197 |
| 4 | 1 | 3 | R | 12.254 | 2.961 |
| 4 | 1 | 4 | R | 10.550 | 2.109 |
| 4 | 1 | 5 | R | 4.351 | 4.334 |
| 5 | 1 | 4 | L | 11.347 | 3.349 |
| 5 | 1 | 5 | L | 12.631 | 3.160 |
| 6 | 1 | 2 | R | 5.745 | 6.159 |
| 6 | 1 | 3 | R | 6.275 | 8.045 |
| 6 | 1 | 4 | R | 8.077 | 4.039 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 6 | 1 | 5 | R | 7.494 | 7.468 |
| 7 | 1 | 3 | L | 6.657 | 9.286 |
| 7 | 1 | 4 | L | 5.215 | 7.802 |
| 7 | 1 | 5 | L | 5.766 | 6.349 |
| 8 | 1 | 2 | R | 5.268 | 5.963 |
| 8 | 1 | 3 | R | 6.053 | 7.690 |
| 8 | 1 | 4 | R | 4.781 | 8.432 |
| 8 | 1 | 5 | R | 6.699 | 7.621 |
| 9 | 1 | 3 | L | n | n |
| 9 | 1 | 4 | L | n | n |
| 9 | 1 | 5 | L | 4.928 | 4.015 |
| 10 | 1 | 2 | R | n | n |
| 10 | 1 | 3 | R | n | n |
| 10 | 1 | 4 | R | n | n |
| 11 | 1 | 2 | R | 9.294 | 2.111 |
| 11 | 1 | 3 | R | 10.981 | -0.357 |
| 11 | 1 | 4 | R | 11.840 | -0.404 |
| 11 | 1 | 5 | R | 11.530 | 0.652 |
| 12 | 1 | 3 | L | 9.874 | 0.176 |
| 12 | 1 | 4 | L | 10.485 | 0.481 |
| 12 | 1 | 5 | L | 10.702 | -0.052 |
| 12 | 1 | 6 | L | 9.657 | 0.409 |
| 13 | 1 | 2 | L | 10.316 | -0.712 |
| 13 | 1 | 3 | L | 10.316 | 4.007 |
| 13 | 1 | 4 | L | 9.116 | 3.261 |
| 13 | 1 | 5 | L | 8.639 | 2.906 |
| 14 | 1 | 1 | L | n | n |
| 14 | 1 | 2 | L | n | n |
| 14 | 1 | 3 | L | n | n |
| 14 | 1 | 4 | L | n | n |
| 15 | 1 | 2 | R | 7.430 | 1.599 |
| 15 | 1 | 3 | R | 11.281 | 2.520 |
| 15 | 1 | 4 | R | 10.520 | 3.700 |
| 15 | 1 | 5 | R | 10.647 | 2.613 |
| 16 | 1 | 2 | R | 8.483 | 0.731 |
| 16 | 1 | 3 | R | 10.296 | 1.492 |
| 16 | 1 | 4 | R | 11.505 | 3.491 |
| 17 | 1 | 3 | L | 10.530 | -0.926 |
| 17 | 1 | 4 | L | 11.193 | 0.234 |
| 17 | 1 | 5 | L | 11.086 | 0.873 |
| 17 | 1 | 6 | L | 10.735 | 2.540 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 18 | 1 | 3 | L | 11.213 | 3.159 |
| 18 | 1 | 4 | L | 10.481 | 5.241 |
| 18 | 1 | 5 | L | 6.035 | 3.564 |
| 18 | 1 | 6 | L | 8.044 | 3.252 |
| 19 | 1 | 1 | R | 10.364 | 1.068 |
| 19 | 1 | 2 | R | 11.271 | 2.252 |
| 19 | 1 | 3 | R | 13.504 | 0.541 |
| 20 | 1 | 3 | L | 10.647 | -1.268 |
| 20 | 1 | 4 | L | 11.876 | -1.628 |
| 20 | 1 | 5 | L | 10.540 | -0.522 |
| 20 | 1 | 6 | L | 9.779 | 0.804 |
| 21 | 1 | 3 | R | 5.331 | 9.641 |
| 21 | 1 | 4 | R | 6.436 | 8.763 |
| 21 | 1 | 5 | R | 9.238 | 7.516 |
| 21 | 1 | 6 | R | 8.330 | 7.576 |
| 22 | 1 | 3 | R | n | n |
| 22 | 1 | 4 | R | 10.399 | 0.069 |
| 22 | 1 | 5 | R | 11.151 | 1.039 |
| 22 | 1 | 6 | R | 10.388 | 1.230 |
| 23 | 1 | 3 | L | n | n |
| 23 | 1 | 4 | L | n | n |
| 23 | 1 | 5 | L | n | n |
| 23 | 1 | 6 | L | n | n |
| 24 | 1 | 4 | L | 12.704 | 1.116 |
| 24 | 1 | 5 | L | 11.885 | 0.834 |
| 24 | 1 | 6 | L | 11.681 | 1.794 |
| 24 | 1 | 7 | L | 5.977 | 4.012 |
| 25 | 1 | 3 | L | 9.535 | 7.208 |
| 25 | 1 | 4 | L | 8.955 | 6.961 |
| 25 | 1 | 5 | L | 7.729 | 7.197 |
| 25 | 1 | 6 | L | 9.847 | 7.772 |
| 26 | 1 | 2 | L | 2.854 | 3.629 |
| 26 | 1 | 3 | L | n | n |
| 26 | 1 | 4 | L | 8.064 | 0.484 |
| 26 | 1 | 5 | L | n | n |
| 27 | 1 | 3 | R | n | n |
| 27 | 1 | 4 | R | 12.402 | 4.953 |
| 27 | 1 | 5 | R | 8.892 | 4.446 |
| 27 | 1 | 6 | R | n | n |
| 28 | 1 | 3 | R | 11.817 | 0.634 |
| 28 | 1 | 4 | R | 11.817 | -1.794 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 28 | 1 | 5 | R | 12.929 | -1.775 |
| 28 | 1 | 6 | R | 9.994 | -0.814 |
| 29 | 1 | 2 | R | 6.053 | 9.715 |
| 29 | 1 | 3 | R | 7.176 | 8.485 |
| 29 | 1 | 4 | R | 9.201 | 8.332 |
| 29 | 1 | 5 | R | 7.939 | 7.489 |
| 30 | 1 | 4 | R | 10.328 | -0.531 |
| 30 | 1 | 5 | R | 10.532 | -0.113 |
| 30 | 1 | 6 | R | 9.402 | -0.802 |
| 30 | 1 | 7 | R | 6.893 | 1.074 |
| 31 | 1 | 3 | R | n | n |
| 31 | 1 | 4 | R | 10.524 | 1.338 |
| 31 | 1 | 5 | R | 10.750 | 0.925 |
| 31 | 1 | 6 | R | 10.750 | 0.925 |
| 32 | 1 | 3 | L | 6.117 | 5.864 |
| 32 | 1 | 4 | L | 7.654 | 4.881 |
| 32 | 1 | 5 | L | 7.654 | 5.665 |
| 32 | 1 | 6 | L | 6.740 | 5.208 |
| 33 | 1 | 2 | R | 10.240 | 0.493 |
| 33 | 1 | 3 | R | 11.258 | -0.260 |
| 33 | 1 | 4 | R | 9.963 | -0.432 |
| 33 | 1 | 5 | R | 9.609 | -0.664 |
| 34 | 1 | 3 | R | 7.525 | 2.516 |
| 34 | 1 | 4 | R | 11.696 | 6.955 |
| 34 | 1 | 5 | R | 10.524 | 6.649 |
| 34 | 1 | 6 | R | 10.922 | 5.741 |
| 35 | 1 | 3 | R | 9.690 | 2.775 |
| 35 | 1 | 4 | R | 9.500 | 1.540 |
| 35 | 1 | 5 | R | 9.290 | 1.905 |
| 35 | 1 | 6 | R | 11.950 | 2.265 |
| 36 | 1 | 3 | L | 8.804 | 2.962 |
| 36 | 1 | 4 | L | 8.224 | 5.552 |
| 36 | 1 | 5 | L | 7.934 | 5.827 |
| 36 | 1 | 6 | L | n | n |
| 37 | 1 | 3 | L | n | n |
| 37 | 1 | 4 | L | 9.688 | -0.124 |
| 37 | 1 | 5 | L | 12.710 | 0.093 |
| 38 | 1 | 3 | L | 10.300 | 4.700 |
| 38 | 1 | 4 | L | 9.740 | 5.640 |
| 38 | 1 | 5 | L | 8.980 | 5.790 |
| 38 | 1 | 6 | L | 8.130 | 4.995 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 39 | 1 | 3 | L | 10.090 | -0.705 |
| 39 | 1 | 4 | L | 10.660 | -0.550 |
| 39 | 1 | 5 | L | 11.560 | 0.260 |
| 39 | 1 | 6 | L | 11.060 | 2.490 |
| 40 | 1 | 5 | R | 9.280 | 1.130 |
| 40 | 1 | 6 | R | 10.470 | 1.605 |
| 40 | 1 | 7 | R | 12.670 | -0.395 |
| 40 | 1 | 8 | R | 11.170 | -0.825 |
| 41 | 1 | 4 | R | 13.660 | -1.530 |
| 41 | 1 | 5 | R | 12.050 | 0.335 |
| 41 | 1 | 6 | R | n | n |
| 41 | 1 | 7 | R | n | n |
| 42 | 1 | 3 | L | 6.310 | 4.045 |
| 42 | 1 | 4 | L | 8.180 | 3.330 |
| 42 | 1 | 5 | L | 8.710 | 5.435 |
| 42 | 1 | 6 | L | 7.900 | 7.040 |
| 43 | 1 | 3 | R | 9.900 | 2.380 |
| 43 | 1 | 4 | R | 9.900 | 2.380 |
| 43 | 1 | 5 | R | 8.740 | 2.100 |
| 43 | 1 | 6 | R | 10.200 | -0.500 |
| 44 | 1 | 3 | R | 9.890 | -0.325 |
| 44 | 1 | 4 | R | 12.020 | 5.270 |
| 44 | 1 | 5 | R | 10.540 | 4.070 |
| 44 | 1 | 6 | R | 11.050 | 3.765 |
| 45 | 1 | 4 | L | 9.560 | 0.690 |
| 45 | 1 | 5 | L | 10.930 | 0.435 |
| 45 | 1 | 6 | L | 12.120 | 2.940 |
| 45 | 1 | 7 | L | 8.490 | 1.805 |
| 46 | 1 | 4 | R | 10.510 | 0.715 |
| 46 | 1 | 5 | R | 10.680 | 1.030 |
| 46 | 1 | 6 | R | 10.870 | -0.185 |
| 46 | 1 | 7 | R | 9.430 | 1.275 |
| 47 | 1 | 3 | R | 8.228 | 0.719 |
| 47 | 1 | 4 | R | 8.228 | -0.481 |
| 47 | 1 | 5 | R | 9.522 | -0.704 |
| 47 | 1 | 6 | R | n | n |
| 48 | 1 | 3 | R | 8.470 | -1.045 |
| 48 | 1 | 4 | R | 9.600 | 0.290 |
| 48 | 1 | 5 | R | 9.470 | 1.095 |
| 48 | 1 | 6 | R | 10.050 | 1.255 |
| 49 | 1 | 3 | L | 6.550 | 6.045 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 49 | 1 | 4 | L | 7.450 | 5.445 |
| 49 | 1 | 5 | L | 7.450 | 6.595 |
| 49 | 1 | 6 | L | 8.890 | 8.085 |
| 50 | 1 | 3 | R | 13.570 | 1.115 |
| 50 | 1 | 4 | R | 11.460 | 0.760 |
| 50 | 1 | 5 | R | 11.590 | 0.195 |
| 50 | 1 | 6 | R | 9.770 | 0.885 |
| 51 | 1 | 3 | L | 12.670 | 2.025 |
| 51 | 1 | 4 | L | 13.100 | 1.040 |
| 51 | 1 | 5 | L | 11.460 | -0.700 |
| 51 | 1 | 6 | L | 10.940 | -0.210 |
| 52 | 1 | 2 | R | n | n |
| 52 | 1 | 3 | R | 9.570 | -0.865 |
| 52 | 1 | 4 | R | 8.780 | -0.440 |
| 52 | 1 | 5 | R | 9.110 | -0.285 |
| 53 | 1 | 4 | R | 9.220 | 2.850 |
| 53 | 1 | 5 | R | 9.660 | 0.410 |
| 53 | 1 | 6 | R | 10.800 | -1.080 |
| 53 | 1 | 7 | R | 9.730 | -0.745 |
| 54 | 1 | 2 | L | 11.080 | -2.120 |
| 54 | 1 | 3 | L | 11.080 | -1.430 |
| 54 | 1 | 4 | L | 10.680 | -0.780 |
| 54 | 1 | 5 | L | 9.800 | 1.890 |
| 55 | 1 | 2 | L | 9.840 | -1.320 |
| 55 | 1 | 3 | L | 11.800 | -1.000 |
| 55 | 1 | 4 | L | 14.460 | -0.100 |
| 55 | 1 | 5 | L | 11.640 | -1.010 |
| 56 | 1 | 3 | R | 12.570 | 1.925 |
| 56 | 1 | 4 | R | 12.320 | 0.570 |
| 56 | 1 | 5 | R | 12.320 | 0.160 |
| 56 | 1 | 6 | R | 12.200 | -0.550 |
| 57 | 1 | 3 | L | 6.360 | 6.050 |
| 57 | 1 | 4 | L | 7.020 | 7.760 |
| 57 | 1 | 5 | L | 6.790 | 5.885 |
| 57 | 1 | 6 | L | 7.120 | 4.720 |
| 58 | 1 | 2 | R | 8.147 | 0.706 |
| 58 | 1 | 3 | R | 8.317 | -0.407 |
| 58 | 1 | 4 | R | 9.266 | -0.090 |
| 58 | 1 | 5 | R | 9.266 | 0.904 |
| 1 | 2 | 3 | R | 10.243 | 8.882 |
| 1 | 2 | 4 | R | 2.011 | 7.853 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 1 | 2 | 5 | R | n | n |
| 1 | 2 | 6 | R | n | n |
| 2 | 2 | 3 | L | 6.998 | 5.423 |
| 2 | 2 | 4 | L | 8.374 | 4.993 |
| 2 | 2 | 5 | L | 7.977 | 5.192 |
| 2 | 2 | 6 | L | 7.794 | 5.671 |
| 3 | 2 | 4 | R | 10.230 | 8.395 |
| 3 | 2 | 5 | R | 8.070 | 7.555 |
| 3 | 2 | 6 | R | 7.090 | 6.735 |
| 4 | 2 | 2 | R | 4.804 | 3.498 |
| 4 | 2 | 3 | R | 5.314 | 7.716 |
| 4 | 2 | 4 | R | 8.192 | 6.675 |
| 4 | 2 | 5 | R | 5.435 | 4.622 |
| 5 | 2 | 4 | L | 11.778 | 5.236 |
| 5 | 2 | 5 | L | 13.063 | 5.103 |
| 6 | 2 | 2 | R | 6.720 | 4.219 |
| 6 | 2 | 3 | R | 7.420 | 5.936 |
| 6 | 2 | 4 | R | 6.530 | 5.194 |
| 6 | 2 | 5 | R | 6.530 | 6.720 |
| 7 | 2 | 3 | L | 7.049 | 10.107 |
| 7 | 2 | 4 | L | 8.554 | 5.337 |
| 7 | 2 | 5 | L | 6.212 | 7.208 |
| 8 | 2 | 2 | R | 7.060 | 4.897 |
| 8 | 2 | 3 | R | 8.628 | 5.332 |
| 8 | 2 | 4 | R | 5.470 | 6.508 |
| 8 | 2 | 5 | R | 3.805 | 7.786 |
| 9 | 2 | 3 | L | 5.168 | 5.841 |
| 9 | 2 | 4 | L | 4.773 | 4.085 |
| 9 | 2 | 5 | L | 7.071 | 3.536 |
| 10 | 2 | 2 | R | 9.311 | 2.735 |
| 10 | 2 | 3 | R | 12.431 | 2.930 |
| 10 | 2 | 4 | R | 9.077 | 3.651 |
| 11 | 2 | 2 | R | 7.007 | 5.749 |
| 11 | 2 | 3 | R | 10.143 | 0.052 |
| 11 | 2 | 4 | R | 11.457 | 0.264 |
| 11 | 2 | 5 | R | 11.323 | 0.787 |
| 12 | 2 | 3 | L | 10.443 | -1.889 |
| 12 | 2 | 4 | L | 11.654 | -0.031 |
| 12 | 2 | 5 | L | 12.172 | 0.787 |
| 12 | 2 | 6 | L | 10.650 | 1.930 |
| 13 | 2 | 2 | L | 10.023 | 1.326 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 13 | 2 | 3 | L | 11.476 | 2.852 |
| 13 | 2 | 4 | L | 9.155 | 3.622 |
| 13 | 2 | 5 | L | 8.590 | 1.994 |
| 14 | 2 | 1 | L | 5.740 | 4.319 |
| 14 | 2 | 2 | L | 8.345 | 2.723 |
| 14 | 2 | 3 | L | 6.437 | 2.412 |
| 14 | 2 | 4 | L | 7.584 | 3.361 |
| 15 | 2 | 2 | R | 8.414 | 2.043 |
| 15 | 2 | 3 | R | 8.931 | 3.686 |
| 15 | 2 | 4 | R | 9.740 | 3.369 |
| 15 | 2 | 5 | R | 10.920 | 3.617 |
| 16 | 2 | 2 | R | 9.370 | 1.136 |
| 16 | 2 | 3 | R | 10.257 | 2.009 |
| 16 | 2 | 4 | R | 12.636 | 4.524 |
| 17 | 2 | 3 | L | 9.409 | 0.102 |
| 17 | 2 | 4 | L | 9.155 | 0.024 |
| 17 | 2 | 5 | L | 10.101 | 1.550 |
| 17 | 2 | 6 | L | 11.359 | 2.325 |
| 18 | 2 | 3 | L | n | n |
| 18 | 2 | 4 | L | 9.828 | 4.914 |
| 18 | 2 | 5 | L | 8.122 | 5.231 |
| 18 | 2 | 6 | L | 7.215 | 3.179 |
| 19 | 2 | 1 | R | 9.019 | 1.438 |
| 19 | 2 | 2 | R | 10.871 | 0.229 |
| 19 | 2 | 3 | R | 12.743 | -0.882 |
| 20 | 2 | 3 | L | 11.339 | -2.140 |
| 20 | 2 | 4 | L | 11.564 | -0.361 |
| 20 | 2 | 5 | L | 10.764 | 1.307 |
| 20 | 2 | 6 | L | 9.877 | 1.428 |
| 21 | 2 | 3 | R | n | n |
| 21 | 2 | 4 | R | 3.077 | 9.226 |
| 21 | 2 | 5 | R | 7.216 | 9.890 |
| 21 | 2 | 6 | R | 7.824 | 8.351 |
| 22 | 2 | 3 | R | 10.929 | 1.935 |
| 22 | 2 | 4 | R | 10.632 | 0.344 |
| 22 | 2 | 5 | R | 10.229 | 0.758 |
| 22 | 2 | 6 | R | 10.801 | 1.394 |
| 23 | 2 | 3 | L | 8.463 | 2.262 |
| 23 | 2 | 4 | L | 10.052 | 0.658 |
| 23 | 2 | 5 | L | 8.853 | 0.761 |
| 23 | 2 | 6 | L | 6.893 | 0.931 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 24 | 2 | 4 | L | 6.318 | 5.967 |
| 24 | 2 | 5 | L | 6.611 | 4.475 |
| 24 | 2 | 6 | L | 7.166 | 5.397 |
| 24 | 2 | 7 | L | 6.981 | 3.208 |
| 25 | 2 | 3 | L | 7.095 | 5.483 |
| 25 | 2 | 4 | L | 8.976 | 7.616 |
| 25 | 2 | 5 | L | 8.482 | 7.423 |
| 25 | 2 | 6 | L | 7.729 | 6.746 |
| 26 | 2 | 2 | L | 11.167 | 0.613 |
| 26 | 2 | 3 | L | 11.809 | -1.277 |
| 26 | 2 | 4 | L | 10.541 | -0.677 |
| 26 | 2 | 5 | L | 8.861 | 0.274 |
| 27 | 2 | 3 | R | 8.570 | -1.009 |
| 27 | 2 | 4 | R | 12.344 | 4.709 |
| 27 | 2 | 5 | R | 10.433 | 2.184 |
| 27 | 2 | 6 | R | 9.350 | 2.686 |
| 28 | 2 | 3 | R | 11.749 | 0.054 |
| 28 | 2 | 4 | R | 13.416 | -1.073 |
| 28 | 2 | 5 | R | 9.302 | 0.585 |
| 28 | 2 | 6 | R | 7.751 | 0.892 |
| 29 | 2 | 2 | R | 5.353 | 11.814 |
| 29 | 2 | 3 | R | 8.978 | 8.496 |
| 29 | 2 | 4 | R | 8.024 | 9.015 |
| 29 | 2 | 5 | R | 7.791 | 7.510 |
| 30 | 2 | 4 | R | 11.345 | -0.848 |
| 30 | 2 | 5 | R | 10.995 | -0.175 |
| 30 | 2 | 6 | R | 9.243 | 1.367 |
| 30 | 2 | 7 | R | 6.125 | -0.192 |
| 31 | 2 | 3 | R | 8.030 | -0.274 |
| 31 | 2 | 4 | R | 9.890 | 0.828 |
| 31 | 2 | 5 | R | 10.847 | 0.908 |
| 31 | 2 | 6 | R | 11.965 | 0.898 |
| 32 | 2 | 3 | L | 6.031 | 5.208 |
| 32 | 2 | 4 | L | 6.235 | 4.322 |
| 32 | 2 | 5 | L | 5.246 | 7.020 |
| 32 | 2 | 6 | L | 6.106 | 4.924 |
| 33 | 2 | 2 | R | 10.140 | -1.041 |
| 33 | 2 | 3 | R | 10.517 | -0.731 |
| 33 | 2 | 4 | R | 8.701 | -1.240 |
| 33 | 2 | 5 | R | 9.564 | -0.387 |
| 34 | 2 | 3 | R | 8.589 | 2.671 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 34 | 2 | 4 | R | 5.762 | 4.913 |
| 34 | 2 | 5 | R | 12.083 | 6.429 |
| 34 | 2 | 6 | R | 11.847 | 5.225 |
| 35 | 2 | 3 | R | 8.270 | 1.575 |
| 35 | 2 | 4 | R | 10.020 | 0.440 |
| 35 | 2 | 5 | R | 8.560 | 1.430 |
| 35 | 2 | 6 | R | 6.890 | 4.435 |
| 36 | 2 | 3 | L | 8.944 | 5.988 |
| 36 | 2 | 4 | L | 9.138 | 5.063 |
| 36 | 2 | 5 | L | 8.890 | 5.434 |
| 36 | 2 | 6 | L | 6.794 | 5.923 |
| 37 | 2 | 3 | L | 9.015 | 0.502 |
| 37 | 2 | 4 | L | 9.149 | 0.818 |
| 37 | 2 | 5 | L | 9.450 | -0.523 |
| 38 | 2 | 3 | L | 9.360 | 5.528 |
| 38 | 2 | 4 | L | 9.190 | 5.581 |
| 38 | 2 | 5 | L | 8.226 | 4.113 |
| 38 | 2 | 6 | L | 5.480 | 6.535 |
| 39 | 2 | 3 | L | 10.420 | -0.860 |
| 39 | 2 | 4 | L | 10.540 | -0.950 |
| 39 | 2 | 5 | L | 11.080 | 1.240 |
| 39 | 2 | 6 | L | 10.660 | 1.970 |
| 40 | 2 | 5 | R | 10.670 | 0.575 |
| 40 | 2 | 6 | R | 10.220 | 1.370 |
| 40 | 2 | 7 | R | 11.310 | -0.375 |
| 40 | 2 | 8 | R | 9.570 | -0.255 |
| 41 | 2 | 4 | R | 13.700 | -0.790 |
| 41 | 2 | 5 | R | 14.330 | 1.305 |
| 41 | 2 | 6 | R | 11.510 | 0.015 |
| 41 | 2 | 7 | R | 10.180 | -0.900 |
| 42 | 2 | 3 | L | 6.410 | 4.115 |
| 42 | 2 | 4 | L | 8.130 | 3.385 |
| 42 | 2 | 5 | L | 8.800 | 5.500 |
| 42 | 2 | 6 | L | 7.950 | 7.065 |
| 43 | 2 | 3 | R | n | n |
| 43 | 2 | 4 | R | 7.400 | 2.130 |
| 43 | 2 | 5 | R | 4.870 | 3.055 |
| 43 | 2 | 6 | R | 6.720 | 2.100 |
| 44 | 2 | 3 | R | 9.240 | 2.630 |
| 44 | 2 | 4 | R | 10.230 | 3.505 |
| 44 | 2 | 5 | R | 10.280 | 3.890 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 44 | 2 | 6 | R | n | n |
| 45 | 2 | 4 | L | 11.370 | 1.325 |
| 45 | 2 | 5 | L | 11.220 | 1.780 |
| 45 | 2 | 6 | L | 10.160 | 1.660 |
| 45 | 2 | 7 | L | 10.170 | 1.475 |
| 46 | 2 | 4 | R | 10.990 | 2.275 |
| 46 | 2 | 5 | R | 11.340 | -0.910 |
| 46 | 2 | 6 | R | 11.060 | -0.500 |
| 46 | 2 | 7 | R | 7.690 | 0.485 |
| 47 | 2 | 3 | R | 8.870 | 0.699 |
| 47 | 2 | 4 | R | 8.559 | -0.450 |
| 47 | 2 | 5 | R | 9.201 | -1.475 |
| 47 | 2 | 6 | R | 10.412 | -0.869 |
| 48 | 2 | 3 | R | 8.040 | -1.680 |
| 48 | 2 | 4 | R | 8.550 | 0.465 |
| 48 | 2 | 5 | R | 7.340 | 1.700 |
| 48 | 2 | 6 | R | 9.740 | 0.320 |
| 49 | 2 | 3 | L | 5.246 | 4.085 |
| 49 | 2 | 4 | L | 7.450 | 5.187 |
| 49 | 2 | 5 | L | 8.170 | 5.386 |
| 49 | 2 | 6 | L | 7.353 | 4.547 |
| 50 | 2 | 3 | R | 13.390 | 2.215 |
| 50 | 2 | 4 | R | 12.260 | -0.320 |
| 50 | 2 | 5 | R | 10.140 | -0.850 |
| 50 | 2 | 6 | R | 8.880 | -0.340 |
| 51 | 2 | 3 | L | 12.400 | 0.020 |
| 51 | 2 | 4 | L | 10.630 | -2.125 |
| 51 | 2 | 5 | L | 11.390 | -1.115 |
| 51 | 2 | 6 | L | 11.990 | -0.345 |
| 52 | 2 | 2 | R | 9.120 | -0.870 |
| 52 | 2 | 3 | R | 9.200 | -1.130 |
| 52 | 2 | 4 | R | 10.040 | 0.190 |
| 52 | 2 | 5 | R | 5.830 | 2.915 |
| 53 | 2 | 4 | R | 8.220 | 1.840 |
| 53 | 2 | 5 | R | 9.950 | 0.695 |
| 53 | 2 | 6 | R | 9.680 | -0.500 |
| 53 | 2 | 7 | R | 13.170 | 2.515 |
| 54 | 2 | 2 | L | 11.530 | -0.225 |
| 54 | 2 | 3 | L | 10.320 | -0.840 |
| 54 | 2 | 4 | L | 10.450 | 0.315 |
| 54 | 2 | 5 | L | 9.250 | 0.715 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 55 | 2 | 2 | L | 9.570 | -1.815 |
| 55 | 2 | 3 | L | 11.620 | 0.060 |
| 55 | 2 | 4 | L | 13.590 | -0.315 |
| 55 | 2 | 5 | L | 10.810 | -1.705 |
| 56 | 2 | 3 | R | 10.580 | 1.630 |
| 56 | 2 | 4 | R | 11.240 | -0.460 |
| 56 | 2 | 5 | R | 13.190 | 0.775 |
| 56 | 2 | 6 | R | 13.600 | 1.770 |
| 57 | 2 | 3 | L | 7.470 | 6.935 |
| 57 | 2 | 4 | L | 8.100 | 8.900 |
| 57 | 2 | 5 | L | 8.270 | 7.355 |
| 57 | 2 | 6 | L | n | n |
| 58 | 2 | 2 | R | 9.515 | -0.509 |
| 58 | 2 | 3 | R | 8.678 | -0.079 |
| 58 | 2 | 4 | R | 9.390 | 0.288 |
| 58 | 2 | 5 | R | 9.752 | 2.356 |
| 1 | 3 | 3 | R | 9.912 | 7.881 |
| 1 | 3 | 4 | R | 3.100 | 8.130 |
| 1 | 3 | 5 | R | 1.954 | 5.997 |
| 1 | 3 | 6 | R | 2.109 | 4.682 |
| 2 | 3 | 3 | L | 5.440 | 4.795 |
| 2 | 3 | 4 | L | 6.945 | 6.332 |
| 2 | 3 | 5 | L | 4.515 | 5.074 |
| 2 | 3 | 6 | L | 5.461 | 5.268 |
| 3 | 3 | 4 | R | 9.670 | 8.315 |
| 3 | 3 | 5 | R | 5.920 | 6.450 |
| 3 | 3 | 6 | R | 6.370 | 6.385 |
| 4 | 3 | 2 | R | 4.793 | 5.972 |
| 4 | 3 | 3 | R | 7.993 | 7.229 |
| 4 | 3 | 4 | R | 5.624 | 5.834 |
| 4 | 3 | 5 | R | 4.306 | 3.969 |
| 5 | 3 | 4 | L | 10.970 | 7.887 |
| 5 | 3 | 5 | L | 13.063 | 9.520 |
| 6 | 3 | 2 | R | 6.625 | 5.910 |
| 6 | 3 | 3 | R | 6.392 | 6.217 |
| 6 | 3 | 4 | R | 5.841 | 6.662 |
| 6 | 3 | 5 | R | 5.364 | 7.229 |
| 7 | 3 | 3 | L | 5.491 | 9.190 |
| 7 | 3 | 4 | L | 5.491 | 9.052 |
| 7 | 3 | 5 | L | 5.014 | 8.952 |
| 8 | 3 | 2 | R | n | n |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 8 | 3 | 3 | R | n | n |
| 8 | 3 | 4 | R | n | n |
| 8 | 3 | 5 | R | n | n |
| 9 | 3 | 3 | L | 2.002 | 7.106 |
| 9 | 3 | 4 | L | 4.075 | 4.695 |
| 9 | 3 | 5 | L | 2.926 | 4.776 |
| 10 | 3 | 2 | R | 10.325 | 1.116 |
| 10 | 3 | 3 | R | 12.197 | 4.724 |
| 10 | 3 | 4 | R | 12.197 | 3.349 |
| 11 | 3 | 2 | R | 9.812 | 3.633 |
| 11 | 3 | 3 | R | 9.998 | -0.176 |
| 11 | 3 | 4 | R | 9.646 | -0.900 |
| 11 | 3 | 5 | R | 11.571 | -0.259 |
| 12 | 3 | 3 | L | 10.060 | 0.114 |
| 12 | 3 | 4 | L | 11.406 | 0.124 |
| 12 | 3 | 5 | L | 11.675 | 0.631 |
| 12 | 3 | 6 | L | 9.791 | -0.021 |
| 13 | 3 | 2 | L | 9.555 | 1.297 |
| 13 | 3 | 3 | L | 11.330 | 2.906 |
| 13 | 3 | 4 | L | 10.550 | 3.276 |
| 13 | 3 | 5 | L | 9.233 | 3.593 |
| 14 | 3 | 1 | L | n | n |
| 14 | 3 | 2 | L | 9.959 | 2.779 |
| 14 | 3 | 3 | L | 8.088 | 2.788 |
| 14 | 3 | 4 | L | 8.675 | 2.265 |
| 15 | 3 | 2 | R | 7.537 | 2.715 |
| 15 | 3 | 3 | R | 10.403 | 2.988 |
| 15 | 3 | 4 | R | 10.267 | 3.232 |
| 15 | 3 | 5 | R | 11.242 | 3.018 |
| 16 | 3 | 2 | R | 9.692 | 1.394 |
| 16 | 3 | 3 | R | 10.306 | 1.545 |
| 16 | 3 | 4 | R | 12.665 | 3.573 |
| 17 | 3 | 3 | L | 9.926 | 0.410 |
| 17 | 3 | 4 | L | 12.158 | 0.015 |
| 17 | 3 | 5 | L | 10.111 | -0.804 |
| 17 | 3 | 6 | L | 10.608 | 1.736 |
| 18 | 3 | 3 | L | 12.022 | 3.388 |
| 18 | 3 | 4 | L | 10.452 | 3.988 |
| 18 | 3 | 5 | L | 6.962 | 3.481 |
| 18 | 3 | 6 | L | 5.889 | 0.614 |
| 19 | 3 | 1 | R | 10.004 | 0.136 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 19 | 3 | 2 | R | 11.417 | 0.405 |
| 19 | 3 | 3 | R | 11.739 | -0.527 |
| 20 | 3 | 3 | L | 9.214 | -0.600 |
| 20 | 3 | 4 | L | 10.667 | 0.263 |
| 20 | 3 | 5 | L | 10.988 | 0.307 |
| 20 | 3 | 6 | L | 10.676 | 1.545 |
| 21 | 3 | 3 | R | 3.179 | 8.969 |
| 21 | 3 | 4 | R | 5.176 | 9.975 |
| 21 | 3 | 5 | R | 4.088 | 10.117 |
| 21 | 3 | 6 | R | 4.808 | 10.211 |
| 22 | 3 | 3 | R | 8.946 | 1.314 |
| 22 | 3 | 4 | R | 10.187 | 0.122 |
| 22 | 3 | 5 | R | 11.745 | 1.039 |
| 22 | 3 | 6 | R | 10.897 | 2.374 |
| 23 | 3 | 3 | L | 4.622 | 4.173 |
| 23 | 3 | 4 | L | 9.818 | 1.604 |
| 23 | 3 | 5 | L | 8.921 | 1.419 |
| 23 | 3 | 6 | L | 9.038 | 0.921 |
| 24 | 3 | 4 | L | 6.611 | 4.271 |
| 24 | 3 | 5 | L | 6.230 | 3.651 |
| 24 | 3 | 6 | L | 8.990 | 4.251 |
| 24 | 3 | 7 | L | 6.503 | 1.701 |
| 25 | 3 | 3 | L | 6.816 | 7.547 |
| 25 | 3 | 4 | L | 7.063 | 7.487 |
| 25 | 3 | 5 | L | 7.213 | 8.971 |
| 25 | 3 | 6 | L | 8.073 | 9.874 |
| 26 | 3 | 2 | L | 10.035 | -0.287 |
| 26 | 3 | 3 | L | 9.204 | 1.200 |
| 26 | 3 | 4 | L | 7.482 | 0.536 |
| 26 | 3 | 5 | L | 8.613 | 1.761 |
| 27 | 3 | 3 | R | 8.678 | 1.667 |
| 27 | 3 | 4 | R | 11.388 | 2.233 |
| 27 | 3 | 5 | R | 8.541 | 3.305 |
| 27 | 3 | 6 | R | 9.321 | 2.418 |
| 28 | 3 | 3 | R | 11.983 | -0.132 |
| 28 | 3 | 4 | R | 12.890 | 0.985 |
| 28 | 3 | 5 | R | 12.977 | -1.019 |
| 28 | 3 | 6 | R | 13.104 | -1.102 |
| 29 | 3 | 2 | R | 5.268 | 8.856 |
| 29 | 3 | 3 | R | 6.699 | 9.731 |
| 29 | 3 | 4 | R | 7.759 | 10.388 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 29 | 3 | 5 | R | 6.752 | 7.436 |
| 30 | 3 | 4 | R | 11.153 | -0.175 |
| 30 | 3 | 5 | R | 12.023 | -1.062 |
| 30 | 3 | 6 | R | 8.294 | -0.554 |
| 30 | 3 | 7 | R | 6.656 | 0.277 |
| 31 | 3 | 3 | R | 11.825 | 0.989 |
| 31 | 3 | 4 | R | 10.471 | 0.989 |
| 31 | 3 | 5 | R | 11.331 | 0.989 |
| 31 | 3 | 6 | R | 10.739 | 0.231 |
| 32 | 3 | 3 | L | 5.665 | 6.025 |
| 32 | 3 | 4 | L | 5.472 | 7.444 |
| 32 | 3 | 5 | L | 5.569 | 8.460 |
| 32 | 3 | 6 | L | 6.472 | 5.332 |
| 33 | 3 | 2 | R | 10.605 | 0.421 |
| 33 | 3 | 3 | R | 11.402 | 0.066 |
| 33 | 3 | 4 | R | 10.328 | -0.526 |
| 33 | 3 | 5 | R | 9.465 | -0.017 |
| 34 | 3 | 3 | R | 8.224 | 3.134 |
| 34 | 3 | 4 | R | 7.568 | 4.279 |
| 34 | 3 | 5 | R | 6.429 | 3.849 |
| 34 | 3 | 6 | R | 5.633 | 3.451 |
| 35 | 3 | 3 | R | 9.120 | 0.830 |
| 35 | 3 | 4 | R | 9.250 | 0.605 |
| 35 | 3 | 5 | R | 8.750 | 1.175 |
| 35 | 3 | 6 | R | 11.320 | 1.150 |
| 36 | 3 | 3 | L | 8.299 | 2.989 |
| 36 | 3 | 4 | L | 6.837 | 3.419 |
| 36 | 3 | 5 | L | 8.256 | 4.870 |
| 36 | 3 | 6 | L | 5.644 | 3.080 |
| 37 | 3 | 3 | L | 9.739 | -1.206 |
| 37 | 3 | 4 | L | 10.836 | -0.761 |
| 37 | 3 | 5 | L | 12.596 | -0.109 |
| 38 | 3 | 3 | L | 7.844 | 5.088 |
| 38 | 3 | 4 | L | 8.713 | 4.918 |
| 38 | 3 | 5 | L | 8.597 | 5.030 |
| 38 | 3 | 6 | L | 6.975 | 5.141 |
| 39 | 3 | 3 | L | 9.790 | -0.625 |
| 39 | 3 | 4 | L | 9.950 | 0.095 |
| 39 | 3 | 5 | L | 10.420 | 0.690 |
| 39 | 3 | 6 | L | 10.080 | 1.820 |
| 40 | 3 | 5 | R | 9.040 | 1.330 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 40 | 3 | 6 | R | 9.910 | 0.355 |
| 40 | 3 | 7 | R | 11.510 | -0.765 |
| 40 | 3 | 8 | R | 9.970 | -1.315 |
| 41 | 3 | 4 | R | 13.350 | -1.925 |
| 41 | 3 | 5 | R | 11.560 | -0.350 |
| 41 | 3 | 6 | R | 11.200 | -1.100 |
| 41 | 3 | 7 | R | 11.660 | -1.230 |
| 42 | 3 | 3 | L | 6.680 | 4.010 |
| 42 | 3 | 4 | L | 7.950 | 3.975 |
| 42 | 3 | 5 | L | 8.030 | 5.485 |
| 42 | 3 | 6 | L | 7.550 | 6.395 |
| 43 | 3 | 3 | R | 7.270 | 4.475 |
| 43 | 3 | 4 | R | 6.890 | 3.725 |
| 43 | 3 | 5 | R | 7.650 | 1.235 |
| 43 | 3 | 6 | R | 6.620 | 1.440 |
| 44 | 3 | 3 | R | 9.700 | 2.910 |
| 44 | 3 | 4 | R | 9.000 | 5.080 |
| 44 | 3 | 5 | R | 9.150 | 4.065 |
| 44 | 3 | 6 | R | 9.890 | 4.945 |
| 45 | 3 | 4 | L | 10.550 | -0.555 |
| 45 | 3 | 5 | L | 10.450 | 1.065 |
| 45 | 3 | 6 | L | 10.920 | 1.940 |
| 45 | 3 | 7 | L | 9.180 | 1.130 |
| 46 | 3 | 4 | R | 10.260 | -0.300 |
| 46 | 3 | 5 | R | 9.470 | -0.525 |
| 46 | 3 | 6 | R | 9.470 | -0.075 |
| 46 | 3 | 7 | R | 8.830 | 0.645 |
| 47 | 3 | 3 | R | 8.145 | 1.516 |
| 47 | 3 | 4 | R | 10.060 | -1.873 |
| 47 | 3 | 5 | R | 9.688 | -1.273 |
| 47 | 3 | 6 | R | 8.094 | -0.248 |
| 48 | 3 | 3 | R | 7.160 | -0.250 |
| 48 | 3 | 4 | R | 9.470 | 0.315 |
| 48 | 3 | 5 | R | 10.170 | 0.895 |
| 48 | 3 | 6 | R | 8.570 | -0.475 |
| 49 | 3 | 3 | L | 4.483 | 7.025 |
| 49 | 3 | 4 | L | 6.880 | 7.633 |
| 49 | 3 | 5 | L | 7.181 | 8.245 |
| 49 | 3 | 6 | L | 4.418 | 6.670 |
| 50 | 3 | 3 | R | 13.810 | 1.145 |
| 50 | 3 | 4 | R | 12.050 | -0.115 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 50 | 3 | 5 | R | 11.920 | 0.880 |
| 50 | 3 | 6 | R | 9.690 | 0.305 |
| 51 | 3 | 3 | L | 7.080 | 1.450 |
| 51 | 3 | 4 | L | 11.580 | -0.530 |
| 51 | 3 | 5 | L | 11.520 | -0.230 |
| 51 | 3 | 6 | L | 11.640 | 0.350 |
| 52 | 3 | 2 | R | 10.230 | -0.185 |
| 52 | 3 | 3 | R | 9.480 | -0.440 |
| 52 | 3 | 4 | R | 9.180 | -1.060 |
| 52 | 3 | 5 | R | 9.300 | 0.270 |
| 53 | 3 | 4 | R | 7.050 | 4.245 |
| 53 | 3 | 5 | R | 9.070 | 0.625 |
| 53 | 3 | 6 | R | 9.530 | -0.295 |
| 53 | 3 | 7 | R | 8.480 | 1.210 |
| 54 | 3 | 2 | L | 9.630 | -2.105 |
| 54 | 3 | 3 | L | 10.260 | -0.720 |
| 54 | 3 | 4 | L | 9.790 | -0.185 |
| 54 | 3 | 5 | L | 9.300 | 0.690 |
| 55 | 3 | 2 | L | 9.490 | -0.065 |
| 55 | 3 | 3 | L | 10.160 | 0.040 |
| 55 | 3 | 4 | L | 12.380 | 0.390 |
| 55 | 3 | 5 | L | 12.810 | 1.245 |
| 56 | 3 | 3 | R | 9.790 | 0.605 |
| 56 | 3 | 4 | R | 10.760 | -0.070 |
| 56 | 3 | 5 | R | 11.830 | -0.105 |
| 56 | 3 | 6 | R | 11.830 | 0.435 |
| 57 | 3 | 3 | L | 5.050 | 5.305 |
| 57 | 3 | 4 | L | 6.940 | 7.380 |
| 57 | 3 | 5 | L | 5.580 | 6.740 |
| 57 | 3 | 6 | L | 4.610 | 4.515 |
| 58 | 3 | 2 | R | 10.294 | -0.514 |
| 58 | 3 | 3 | R | 9.436 | -1.237 |
| 58 | 3 | 4 | R | 9.356 | -0.034 |
| 58 | 3 | 5 | R | 9.356 | -0.497 |
| 1 | 4 | 3 | R | 7.466 | 6.137 |
| 1 | 4 | 4 | R | 9.708 | 7.455 |
| 1 | 4 | 5 | R | 10.151 | 2.932 |
| 1 | 4 | 6 | R | 7.318 | 6.998 |
| 2 | 4 | 3 | L | 7.428 | 2.951 |
| 2 | 4 | 4 | L | 7.826 | 4.397 |
| 2 | 4 | 5 | L | 6.558 | 4.332 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 2 | 4 | 6 | L | 7.977 | 5.343 |
| 3 | 4 | 4 | R | 10.340 | 7.670 |
| 3 | 4 | 5 | R | 8.650 | 5.865 |
| 3 | 4 | 6 | R | 7.710 | 6.465 |
| 4 | 4 | 2 | R | 8.513 | 6.946 |
| 4 | 4 | 3 | R | 4.472 | 4.904 |
| 4 | 4 | 4 | R | 10.838 | 4.135 |
| 4 | 4 | 5 | R | 8.380 | 5.341 |
| 5 | 4 | 4 | L | 11.457 | 1.633 |
| 5 | 4 | 5 | L | 13.428 | 5.020 |
| 6 | 4 | 2 | R | 4.908 | 3.970 |
| 6 | 4 | 3 | R | 5.819 | 5.093 |
| 6 | 4 | 4 | R | 5.236 | 6.063 |
| 6 | 4 | 5 | R | 8.045 | 7.828 |
| 7 | 4 | 3 | L | 8.024 | 7.977 |
| 7 | 4 | 4 | L | 6.763 | 5.342 |
| 7 | 4 | 5 | L | 6.243 | 6.991 |
| 8 | 4 | 2 | R | 4.908 | 4.574 |
| 8 | 4 | 3 | R | 3.053 | 6.795 |
| 8 | 4 | 4 | R | 7.081 | 5.268 |
| 8 | 4 | 5 | R | 7.494 | 8.846 |
| 9 | 4 | 3 | L | n | n |
| 9 | 4 | 4 | L | n | n |
| 9 | 4 | 5 | L | n | n |
| 10 | 4 | 2 | R | 11.827 | 2.657 |
| 10 | 4 | 3 | R | 10.462 | 4.266 |
| 10 | 4 | 4 | R | 10.706 | 4.037 |
| 11 | 4 | 2 | R | 10.029 | 3.214 |
| 11 | 4 | 3 | R | 11.054 | -0.921 |
| 11 | 4 | 4 | R | 11.706 | 0.140 |
| 11 | 4 | 5 | R | 11.654 | 2.308 |
| 12 | 4 | 3 | L | 10.474 | -0.342 |
| 12 | 4 | 4 | L | 11.075 | 0.217 |
| 12 | 4 | 5 | L | 12.275 | -0.124 |
| 12 | 4 | 6 | L | 10.609 | 2.510 |
| 13 | 4 | 2 | L | 9.341 | 3.978 |
| 13 | 4 | 3 | L | 9.828 | 1.736 |
| 13 | 4 | 4 | L | 9.204 | 2.018 |
| 13 | 4 | 5 | L | 8.307 | 2.925 |
| 14 | 4 | 1 | L | 9.271 | 2.930 |
| 14 | 4 | 2 | L | 7.565 | 3.783 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 14 | 4 | 3 | L | 8.024 | 3.718 |
| 14 | 4 | 4 | L | 7.336 | 3.668 |
| 15 | 4 | 2 | R | 7.342 | 4.002 |
| 15 | 4 | 3 | R | 9.750 | 3.656 |
| 15 | 4 | 4 | R | 10.618 | 2.979 |
| 15 | 4 | 5 | R | 11.115 | 2.174 |
| 16 | 4 | 2 | R | 10.637 | -0.219 |
| 16 | 4 | 3 | R | 11.144 | 1.311 |
| 16 | 4 | 4 | R | 12.685 | 1.770 |
| 17 | 4 | 3 | L | 8.921 | 0.619 |
| 17 | 4 | 4 | L | 9.575 | 0.449 |
| 17 | 4 | 5 | L | 10.130 | 3.427 |
| 17 | 4 | 6 | L | 12.256 | 4.373 |
| 18 | 4 | 3 | L | 9.857 | 3.096 |
| 18 | 4 | 4 | L | 10.325 | 4.061 |
| 18 | 4 | 5 | L | 7.118 | 2.623 |
| 18 | 4 | 6 | L | 9.185 | 1.697 |
| 19 | 4 | 1 | R | 9.419 | 1.053 |
| 19 | 4 | 2 | R | 11.154 | 2.935 |
| 19 | 4 | 3 | R | 12.841 | -0.522 |
| 20 | 4 | 3 | L | n | n |
| 20 | 4 | 4 | L | n | nn |
| 20 | 4 | 6 | L | n | n |
| 21 | 4 | 3 | R | n | n |
| 21 | 4 | 4 | R | 5.579 | 8.891 |
| 21 | 4 | 5 | R | 6.368 | 10.554 |
| 21 | 4 | 6 | R | 7.722 | 8.951 |
| 22 | 4 | 3 | R | 8.830 | -0.090 |
| 22 | 4 | 4 | R | 10.049 | 0.890 |
| 22 | 4 | 5 | R | 11.300 | -0.053 |
| 22 | 4 | 6 | R | 10.420 | 1.924 |
| 23 | 4 | 3 | L | 8.288 | 0.322 |
| 23 | 4 | 4 | L | 10.550 | 1.628 |
| 23 | 4 | 5 | L | 8.697 | 0.634 |
| 23 | 4 | 6 | L | 10.628 | 1.726 |
| 24 | 4 | 4 | L | 12.275 | 2.384 |
| 24 | 4 | 5 | L | 11.398 | 1.272 |
| 24 | 4 | 6 | L | 10.550 | 0.829 |
| 24 | 4 | 7 | L | 5.441 | 2.116 |
| 25 | 4 | 3 | L | 5.988 | 4.660 |
| 25 | 4 | 4 | L | 7.224 | 7.138 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 25 | 4 | 5 | L | 8.235 | 6.042 |
| 25 | 4 | 6 | L | 7.772 | 6.584 |
| 26 | 4 | 2 | L | 10.772 | 0.741 |
| 26 | 4 | 3 | L | 12.958 | 0.334 |
| 26 | 4 | 4 | L | 10.078 | 1.568 |
| 26 | 4 | 5 | L | 12.015 | 0.309 |
| 27 | 4 | 3 | R | 7.049 | 2.901 |
| 27 | 4 | 4 | R | 8.278 | 4.743 |
| 27 | 4 | 5 | R | 8.707 | 2.647 |
| 27 | 4 | 6 | R | 8.921 | 4.119 |
| 28 | 4 | 3 | R | 12.480 | 3.988 |
| 28 | 4 | 4 | R | 12.080 | 1.380 |
| 28 | 4 | 5 | R | 9.750 | 0.663 |
| 28 | 4 | 6 | R | 10.511 | 0.322 |
| 29 | 4 | 2 | R | 5.046 | 10.674 |
| 29 | 4 | 3 | R | 6.699 | 7.908 |
| 29 | 4 | 4 | R | 7.176 | 7.680 |
| 29 | 4 | 5 | R | 7.855 | 7.097 |
| 30 | 4 | 4 | R | 11.255 | -0.927 |
| 30 | 4 | 5 | R | 11.345 | 0.362 |
| 30 | 4 | 6 | R | 9.277 | -2.051 |
| 30 | 4 | 7 | R | 9.707 | -0.322 |
| 31 | 4 | 3 | R | 9.922 | 0.564 |
| 31 | 4 | 4 | R | 10.524 | 1.844 |
| 31 | 4 | 5 | R | 11.685 | 0.629 |
| 31 | 4 | 6 | R | 10.965 | 1.129 |
| 32 | 4 | 3 | L | 6.783 | 5.391 |
| 32 | 4 | 4 | L | 8.998 | 3.875 |
| 32 | 4 | 5 | L | 7.170 | 5.499 |
| 32 | 4 | 6 | L | 6.063 | 5.074 |
| 33 | 4 | 2 | R | 9.122 | 0.985 |
| 33 | 4 | 3 | R | 9.410 | -0.996 |
| 33 | 4 | 4 | R | 9.930 | -0.504 |
| 33 | 4 | 5 | R | 7.672 | -0.349 |
| 34 | 4 | 3 | R | 7.224 | 1.860 |
| 34 | 4 | 4 | R | 9.568 | 5.988 |
| 34 | 4 | 5 | R | 10.363 | 6.977 |
| 34 | 4 | 6 | R | 12.158 | 4.338 |
| 35 | 4 | 3 | R | 10.040 | 1.790 |
| 35 | 4 | 4 | R | 10.140 | 2.180 |
| 35 | 4 | 5 | R | 7.070 | 1.595 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 35 | 4 | 6 | R | 7.070 | 4.355 |
| 36 | 4 | 3 | L | 8.428 | 1.226 |
| 36 | 4 | 4 | L | 7.654 | 3.096 |
| 36 | 4 | 5 | L | 5.225 | 3.709 |
| 36 | 4 | 6 | L | 6.902 | 4.504 |
| 37 | 4 | 3 | L | 8.911 | -0.160 |
| 37 | 4 | 4 | L | 10.588 | 0.191 |
| 37 | 4 | 5 | L | 11.820 | 1.480 |
| 38 | 4 | 3 | L | 9.275 | 7.012 |
| 38 | 4 | 4 | L | 8.872 | 5.761 |
| 38 | 4 | 5 | L | 7.452 | 4.648 |
| 38 | 4 | 6 | L | 6.222 | 4.839 |
| 39 | 4 | 3 | L | 10.600 | -0.330 |
| 39 | 4 | 4 | L | 10.110 | 0.355 |
| 39 | 4 | 5 | L | 11.400 | 0.850 |
| 39 | 4 | 6 | L | 11.740 | 3.390 |
| 40 | 4 | 5 | R | 11.440 | 1.470 |
| 40 | 4 | 6 | R | 11.020 | 1.090 |
| 40 | 4 | 7 | R | 11.070 | -1.065 |
| 40 | 4 | 8 | R | 11.460 | -0.270 |
| 41 | 4 | 4 | R | 13.760 | 0.160 |
| 41 | 4 | 5 | R | 13.450 | 1.785 |
| 41 | 4 | 6 | R | 13.500 | -0.890 |
| 41 | 4 | 7 | R | 12.080 | -1.350 |
| 42 | 4 | 3 | L | 6.920 | 4.410 |
| 42 | 4 | 4 | L | 8.320 | 3.630 |
| 42 | 4 | 5 | L | 8.500 | 4.860 |
| 42 | 4 | 6 | L | 8.140 | 5.980 |
| 43 | 4 | 3 | R | 10.230 | 2.905 |
| 43 | 4 | 4 | R | 8.570 | 1.645 |
| 43 | 4 | 5 | R | 10.020 | 1.670 |
| 43 | 4 | 6 | R | 10.530 | 1.445 |
| 44 | 4 | 3 | R | 9.860 | 4.000 |
| 44 | 4 | 4 | R | 10.810 | 2.365 |
| 44 | 4 | 5 | R | 11.580 | 2.820 |
| 44 | 4 | 6 | R | 11.030 | 3.825 |
| 45 | 4 | 4 | L | 9.880 | 2.390 |
| 45 | 4 | 5 | L | 8.680 | 3.070 |
| 45 | 4 | 6 | L | 11.030 | 1.995 |
| 45 | 4 | 7 | L | 10.130 | 2.575 |
| 46 | 4 | 4 | R | 11.420 | 1.560 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 46 | 4 | 5 | R | 10.670 | 0.785 |
| 46 | 4 | 6 | R | 9.850 | 0.085 |
| 46 | 4 | 7 | R | 9.390 | 0.285 |
| 47 | 4 | 3 | R | 8.704 | 1.568 |
| 47 | 4 | 4 | R | 9.770 | -1.180 |
| 47 | 4 | 5 | R | 10.029 | -0.543 |
| 47 | 4 | 6 | R | 9.263 | -0.212 |
| 48 | 4 | 3 | R | 7.080 | -1.160 |
| 48 | 4 | 4 | R | 10.280 | 1.000 |
| 48 | 4 | 5 | R | 9.820 | 0.490 |
| 48 | 4 | 6 | R | 10.140 | 0.830 |
| 49 | 4 | 3 | L | 6.332 | 5.380 |
| 49 | 4 | 4 | L | 6.794 | 6.246 |
| 49 | 4 | 5 | L | 7.772 | 5.950 |
| 49 | 4 | 6 | L | 4.924 | 6.751 |
| 50 | 4 | 3 | R | 11.360 | 2.690 |
| 50 | 4 | 4 | R | 10.850 | 0.385 |
| 50 | 4 | 5 | R | 10.180 | 0.620 |
| 50 | 4 | 6 | R | 7.900 | 1.400 |
| 51 | 4 | 3 | L | 12.720 | -0.470 |
| 51 | 4 | 4 | L | 10.690 | -2.555 |
| 51 | 4 | 5 | L | 12.520 | -0.650 |
| 51 | 4 | 6 | L | 11.030 | 1.505 |
| 52 | 4 | 2 | R | n | n |
| 52 | 4 | 3 | R | n | n |
| 52 | 4 | 4 | R | n | n |
| 52 | 4 | 5 | R | n | n |
| 53 | 4 | 4 | R | 8.070 | 4.035 |
| 53 | 4 | 5 | R | 10.230 | 1.745 |
| 53 | 4 | 6 | R | 10.310 | 1.495 |
| 53 | 4 | 7 | R | 9.020 | 1.190 |
| 54 | 4 | 2 | L | 9.640 | 0.010 |
| 54 | 4 | 3 | L | 10.320 | 0.570 |
| 54 | 4 | 4 | L | 10.930 | 0.725 |
| 54 | 4 | 5 | L | 9.920 | 1.780 |
| 55 | 4 | 2 | L | 9.160 | -1.760 |
| 55 | 4 | 3 | L | 10.170 | 1.535 |
| 55 | 4 | 4 | L | 13.870 | -0.275 |
| 55 | 4 | 5 | L | 13.250 | -0.245 |
| 56 | 4 | 3 | R | 12.160 | 2.110 |
| 56 | 4 | 4 | R | 13.030 | 0.645 |

| MRI | Ob | slice | side | Disc L | Disc Dis |
|---|---|---|---|---|---|
| 56 | 4 | 5 | R | 14.160 | 0.390 |
| 56 | 4 | 6 | R | 13.970 | 0.295 |
| 57 | 4 | 3 | L | 6.820 | 4.880 |
| 57 | 4 | 4 | L | 7.540 | 6.640 |
| 57 | 4 | 5 | L | 8.490 | 6.095 |
| 57 | 4 | 6 | L | 7.070 | 4.525 |
| 58 | 4 | 2 | R | 9.921 | -0.226 |
| 58 | 4 | 3 | R | 9.921 | 0.486 |
| 58 | 4 | 4 | R | 9.537 | 0.588 |
| 58 | 4 | 5 | R | 8.972 | -1.469 |

## Appendix 9(a)

## Clinical Signs and Symptom Data

**Key:**

| | |
|---|---|
| ant. attrit. | excessive anterior attrition of the incisors and cuspids |
| post. attrit. | excessive posterior attrition of the dentition posterior to the cuspids |
| overjet | horizontal overlap of facial surfaces of incisors measured in mm |
| overbite | vertical overlap of incisal edges measured in mm |
| score (0;1) | 0 - a negative signs or symptom detected; 1- a positive sign or symptom |

| No. | Sex | Dentition | | Occl. Contacts | |
|---|---|---|---|---|---|
| | | ant. attrit. | post. attrit. | overjet | overbite |
| 10631 | f | 0 | 0 | 3 | 2 |
| 10734 | m | 1 | 0 | 1 | 2 |
| 9309 | m | 1 | 0 | 6 | 6 |
| 10140 | f | 0 | 0 | 4 | -2 |
| 10716 | f | n | n | 5 | 7 |
| 10962 | m | 0 | 0 | 3 | 3 |
| 7767 | m | 1 | 1 | 5 | 4 |
| 9938 | m | 0 | 0 | 5 | 6 |
| 10569 | f | 0 | 0 | 5 | 6 |
| 10794 | f | 1 | 0 | 2 | 8 |
| 10495 | m | 0 | 0 | 1 | 4 |
| 9247 | m | 0 | 0 | 3 | 6 |
| 9559 | m | 1 | 1 | 5 | 5 |
| 10110 | f | 0 | 0 | 1 | 1 |
| 10491 | f | 0 | 0 | 5 | 7 |
| 9467 | f | 0 | 0 | 3 | 5 |
| 10570 | m | n | n | n | n |
| 10515 | f | 0 | 0 | 4 | 7 |
| 9700 | m | n | n | 7 | 3 |
| 10369 | m | n | n | n | n |
| 10392 | f | 1 | 1 | 2 | 4 |
| 10713 | f | 0 | 0 | 3 | 4 |
| 9129 | m | 0 | 0 | 7 | 5 |
| 9713 | f | 0 | 0 | 6 | 8 |
| 7702 | f | n | n | n | n |
| 10575 | m | 0 | 0 | 6 | 2 |
| 10576 | m | 0 | 0 | 6 | 2 |

| No. | Sex | Dentition |  | Occl. Contacts |  |
|---|---|---|---|---|---|
|  |  | ant. attrit. | post. attrit. | overjet | overbite |
| 9273 | f | 0 | 0 | 2 | 3 |
| 10574 | m | 0 | 0 | 6 | 5 |
| 9945 | m | 0 | 0 | 2 | 4 |
| 10741 | f | 0 | 0 | 4 | 5 |
| 10568 | m | n | n | 4 | 2 |
| 10960 | m | 0 | 0 | 3 | 9 |
| 10596 | f | 0 | 0 | 3 | 7 |
| 6229 | f | 0 | 1 | -1 | 6 |
| 9872 | m | 0 | 0 | 0 | 0 |
| 10642 | m | 0 | 1 | 2 | 2 |
| 10549 | f | 0 | 0 | 2 | 3 |
| 11111 | m | 0 | 0 | 7 | 6 |
| 9903 | f | 0 | 0 | 2 | 4 |
| 10959 | f | 0 | 0 | 6 | 3 |
| 10714 | f | n | n | 5 | 1 |
| 10878 | m | 0 | 0 | 3 | 3 |
| 10969 | m | 0 | 0 | 10 | 6 |
| 10793 | f | 0 | 0 | 3 | 3 |
| 10573 | f | 0 | 0 | 5 | 4 |
| 20000 | m | n | n | 1 | 1 |
| 9984 | f | 0 | 0 | 3 | 2 |
| 7703 | f | n | n | n | n |
| 9988 | m | 0 | 0 | 6 | 4 |
| 10572 | f | 0 | 0 | 5 | 4 |
| 10595 | f | 1 | 0 | 2 | 5 |
| 9087 | f | 0 | 0 | 2 | 4 |
| 10882 | f | 0 | 0 | 2 | 4 |
| 9919 | f | 0 | 0 | 4 | 4 |
| 10346 | f | 0 | 1 | 2 | 1 |
| 9064 | f | 0 | 0 | 5 | 3 |
| 10733 | f | 0 | 0 | 6 | 5 |
| 9093 | f | 0 | 0 | 2 | 2 |
| 5748 | f | 0 | 0 | 0 | -10 |
| 10233 | f | 1 | 1 | 3 | 1 |
| 10176 | f | 0 | 0 | 6 | 1 |
| 10050 | f | 0 | 0 | 7 | -2 |
| 10791 | m | 0 | 0 | 5 | 2 |
| 10354 | f | 0 | 0 | 4 | 3 |
| 10553 | m | 0 | 0 | 4 | 6 |
| 10788 | f | 0 | 0 | 3 | 3 |

| No. | Sex | Dentition | | Occl. Contacts | |
|---|---|---|---|---|---|
| | | ant. attrit. | post. attrit. | overjet | overbite |
| 10399 | f | 0 | 0 | 6 | 6 |
| 10485 | f | 3 | 0 | 3 | 4 |
| 10554 | f | 0 | 0 | 6 | 8 |
| 6796 | m | 0 | 0 | 1 | 2 |
| 10671 | m | 0 | 0 | 3 | 5 |
| 10736 | m | 0 | 0 | 7 | 4 |
| 4703 | f | n | n | n | n |
| 10666 | m | 0 | 0 | 4 | 9 |
| 9985 | f | 0 | 1 | 3 | 4 |
| 9344 | f | 0 | 0 | 0 | 0 |
| 10639 | m | 0 | 0 | 15 | 5 |
| 4381 | f | 0 | 1 | 4 | 2 |
| 9411 | m | 0 | 0 | 1 | 5 |
| 10670 | m | 0 | 0 | 7 | 8 |
| 9161 | m | 1 | 0 | 2 | 5 |
| 10638 | m | 0 | 0 | 7 | 2 |
| 9244 | f | 0 | 2 | 7 | 4 |
| 10646 | f | 0 | 0 | 2 | 2 |
| 10645 | f | 0 | 0 | 3 | 3 |
| 4005 | f | 1 | 1 | 6 | 7 |
| 11440 | f | n | n | 5 | 5 |
| 10555 | f | 0 | 0 | 2 | 4 |
| 11108 | m | 0 | 0 | 7 | 2 |
| 9124 | m | 0 | 0 | 4 | 4 |
| 10423 | m | 0 | 0 | 3 | 6 |
| 10837 | m | 0 | 0 | 4 | 6 |
| 11075 | f | 0 | 0 | 4 | 5 |
| 9382 | m | 1 | 1 | 2 | 4 |
| 11146 | f | 0 | 0 | 6 | 4 |
| 10626 | m | 0 | 0 | 4 | 5 |
| 9163 | m | 0 | 0 | 7 | 1 |
| 10667 | f | 0 | 0 | 2 | 3 |
| 9274 | f | 0 | 0 | 5 | -1 |
| 6429 | f | 0 | 0 | 6 | 0 |
| 10877 | f | 0 | 0 | 6 | 0 |
| 10879 | m | 0 | 0 | 5 | 5 |
| 10740 | f | 0 | 0 | 3 | 3 |
| 10133 | f | 0 | 0 | 4 | 6 |
| 10989 | f | 0 | 1 | 3 | 0 |
| 5105 | f | 1 | 1 | 4 | 5 |

| No. | Sex | Dentition | | Occl. Contacts | |
|---|---|---|---|---|---|
| | | ant. attrit. | post. attrit. | overjet | overbite |
| 10047 | m | 0 | 0 | 9 | 6 |
| 10517 | f | 0 | 0 | 4 | 6 |
| 7749 | m | 0 | 0 | 9 | 4 |
| 9702 | f | n | n | 9 | 3 |
| 9092 | f | n | n | n | n |
| 11048 | f | 0 | 0 | 6 | 3 |
| 10640 | m | 0 | 0 | 6 | 7 |
| 10840 | f | 0 | 0 | 3 | 2 |
| 10647 | f | 0 | 0 | 2 | 1 |
| 9479 | f | 0 | 0 | 1 | 2 |
| 10720 | f | 0 | 1 | 1 | 4 |
| 10282 | f | 1 | 1 | 2 | 4 |
| 9284 | m | 0 | 0 | 8 | 4 |
| 10737 | m | 0 | 0 | 8 | 5 |
| 10839 | f | 1 | 1 | 4 | 6 |
| 11004 | f | 0 | 0 | 3 | 4 |
| 10071 | m | 0 | 0 | 3 | 4 |
| 9340 | f | 0 | 1 | 5 | 3 |
| 10627 | m | 0 | 0 | 2 | 3 |
| 9873 | f | 0 | 0 | 1 | 2 |
| 9347 | m | 0 | 0 | 1 | 3 |
| 10174 | m | 0 | 0 | 3 | 5 |
| 9128 | f | 1 | 0 | 5 | 5 |
| 10284 | m | 0 | 0 | -2 | 2 |
| 9164 | f | 0 | 0 | 4 | 3 |
| 9125 | f | n | n | 4 | 4 |
| 10112 | f | 0 | 0 | 2 | 5 |
| 9088 | f | 0 | 0 | 3 | 5 |
| 10833 | f | 0 | 0 | 3 | 7 |
| 9910 | f | 0 | 0 | -2 | 2 |
| 9162 | f | 1 | 0 | 2 | 4 |
| 9062 | f | 0 | 0 | 3 | 0 |
| 10254 | f | 0 | 0 | 3 | 3 |
| 10998 | f | 0 | 0 | 7 | 4 |
| 10589 | f | 0 | 1 | 6 | 0 |
| 10048 | f | 0 | 0 | 8 | 4 |
| 10919 | f | 1 | 0 | 2 | 5 |
| 10571 | m | 0 | 0 | 8 | 4 |
| 11080 | m | 0 | 0 | 10 | 3 |
| 10643 | m | 0 | 1 | 5 | 0 |

| No. | Sex | Dentition |  | Occl. Contacts |  |
|---|---|---|---|---|---|
|  |  | ant. attrit. | post. attrit. | overjet | overbite |
| 10447 | f | 1 | 1 | 7 | 2 |
| 11077 | f | 0 | 0 | 3 | 4 |
| 10141 | f | 0 | 0 | 2 | 4 |
| 10732 | f | 0 | 0 | 3 | 3 |
| 10315 | f | 0 | 0 | 1 | 1 |
| 10629 | f | 0 | 0 | 5 | 4 |
| 9606 | m | 0 | 0 | 8 | 1 |
| 10344 | f | 0 | 0 | 8 | 6 |
| 9733 | m | n | n | 1 | 1 |
| 9202 | m | 1 | 0 | 1 | 4 |
| 10445 | m | 0 | 0 | 0 | -1 |
| 9650 | f | 0 | 0 | 5 | -3 |
| 11336 | m | n | n | 11 | -2 |

## Appendix 9(b)

## Clinical Signs and Symptoms Continued

**Key:**

| | |
|---|---|
| L pain | Left sided pain experienced on jaw movement |
| R pain | Right sided pain experienced on jaw movement |
| mm | millimetre measurement of mandibular movement |
| n | no response determined for clinical variable |

| No. | Unassisted Open | | | Assisted Open | | | R Laterotrusion | | |
|---|---|---|---|---|---|---|---|---|---|
| | L pain | mm | R pain | L pain | mm | R pain | L pain | mm | R pain |
| 10631 | 0 | 52 | 0 | 0 | 53 | 0 | 0 | 8 | 0 |
| 10734 | 0 | 54 | 0 | 0 | 55 | 0 | 1 | 8 | 0 |
| 9309 | 0 | 49 | 0 | 0 | 51 | 0 | 0 | 9 | 0 |
| 10140 | 1 | 46 | 1 | 1 | 46 | 1 | 0 | 9 | 0 |
| 10716 | 0 | 47 | 0 | 0 | 56 | 0 | 0 | 12 | 0 |
| 10962 | 0 | 55 | 0 | 0 | 56 | 0 | 0 | 11 | 0 |
| 7767 | 1 | 58 | 0 | 1 | 58 | 0 | 0 | 9 | 0 |
| 9938 | 0 | 60 | 0 | 0 | 63 | 0 | 0 | 1 | 0 |
| 10569 | 0 | 45 | 0 | 0 | 50 | 0 | 0 | 8 | 0 |
| 10794 | 0 | 58 | 0 | 1 | 59 | 1 | 0 | 12 | 0 |
| 10495 | 0 | 49 | 0 | 1 | 51 | 0 | 1 | 10 | 0 |
| 9247 | 1 | 60 | 0 | 0 | 60 | 1 | 1 | 13 | 0 |
| 9559 | 0 | 49 | 0 | 0 | 50 | 0 | 0 | 7 | 0 |
| 10110 | 0 | 51 | 0 | 0 | 56 | 0 | 0 | 7 | 0 |
| 10491 | 0 | 47 | 0 | 0 | 48 | 0 | 0 | 7 | 0 |
| 9467 | 0 | 53 | 1 | 0 | 55 | 1 | 0 | 12 | 0 |
| 10570 | n | n | n | n | n | n | n | n | n |
| 10515 | 0 | 49 | 0 | 0 | 51 | 1 | 0 | 10 | 0 |
| 9700 | 0 | 63 | 0 | 0 | 65 | 0 | 0 | 11 | 0 |
| 10369 | n | n | n | n | n | n | n | n | n |
| 10392 | 1 | 44 | 1 | 1 | 49 | 1 | 1 | 7 | 0 |
| 10713 | 0 | 49 | 0 | 0 | 54 | 1 | 0 | 8 | 0 |
| 9129 | 0 | 49 | 0 | 1 | 51 | 1 | 0 | 10 | 0 |
| 9713 | 1 | 48 | 1 | 1 | 52 | 1 | 1 | 12 | 0 |
| 7702 | n | n | n | n | n | n | n | n | n |
| 10575 | 0 | 48 | 0 | 1 | 48 | 1 | 0 | 6 | 0 |
| 10576 | 0 | 45 | 0 | 0 | 46 | 0 | 0 | 6 | 0 |
| 9273 | 0 | 54 | 0 | 0 | 57 | 0 | 0 | 10 | 0 |

| No. | Unassisted Open |  |  | Assisted Open |  |  | R Laterotrusion |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | L pain | mm | R pain | L pain | mm | R pain | L pain | mm | R pain |
| 10574 | 1 | 54 | 1 | 0 | 54 | 1 | 0 | 10 | 0 |
| 9945 | 0 | 54 | 0 | 0 | 56 | 0 | 0 | 12 | 0 |
| 10741 | 1 | 54 | 1 | 1 | 59 | 1 | 0 | 10 | 0 |
| 10568 | 0 | 54 | 0 | 0 | 54 | 0 | 0 | 10 | 0 |
| 10960 | 0 | 39 | 0 | 0 | 42 | 0 | 0 | 10 | 0 |
| 10596 | 1 | 58 | 0 | 1 | 58 | 0 | 0 | 11 | 0 |
| 6229 | 1 | 60 | 1 | 1 | 61 | 1 | 0 | 7 | 0 |
| 9872 | 1 | 60 | 1 | 1 | 61 | 1 | 0 | 8 | 1 |
| 10642 | 0 | 53 | 0 | 1 | 55 | 1 | 0 | 9 | 0 |
| 10549 | 0 | 51 | 0 | 0 | 51 | 0 | 0 | 9 | 0 |
| 11111 | 0 | 50 | 0 | 0 | 50 | 0 | 0 | 11 | 0 |
| 9903 | 1 | 62 | 0 | 1 | 64 | 0 | 0 | 12 | 0 |
| 10959 | 0 | 54 | 0 | 0 | 58 | 1 | 0 | 10 | 0 |
| 10714 | 0 | 54 | 0 | 0 | 57 | 0 | 0 | 8 | 0 |
| 10878 | 0 | 58 | 0 | 0 | 58 | 0 | 0 | 8 | 0 |
| 10969 | 0 | 44 | 0 | 0 | 46 | 0 | 0 | 11 | 0 |
| 10793 | 0 | 50 | 0 | 0 | 50 | 1 | 0 | 10 | 0 |
| 10573 | 0 | 56 | 0 | 0 | 63 | 0 | 0 | 10 | 0 |
| 20000 | 0 | 46 | 0 | 0 | 49 | 0 | 0 | 8 | 0 |
| 9984 | 0 | 38 | 0 | 0 | 43 | 0 | 0 | 7 | 0 |
| 7703 | n | n | n | n | n | n | n | n | n |
| 9988 | 0 | 51 | 0 | 0 | 51 | 0 | 0 | 12 | 0 |
| 10572 | 0 | 54 | 0 | 0 | 54 | 0 | 0 | 6 | 0 |
| 10595 | 0 | 40 | 0 | 1 | 48 | 0 | 0 | 7 | 0 |
| 9087 | 0 | 54 | 0 | 0 | 56 | 1 | 0 | 7 | 0 |
| 10882 | 0 | 45 | 0 | 0 | 46 | 0 | 0 | 9 | 0 |
| 9919 | 1 | 59 | 1 | 1 | 60 | 1 | 0 | 12 | 0 |
| 10346 | 0 | 45 | 1 | 0 | 46 | 1 | 0 | 10 | 0 |
| 9064 | 0 | 52 | 0 | 0 | 54 | 0 | 0 | 8 | 0 |
| 10733 | 0 | 43 | 0 | 0 | 55 | 0 | 1 | 10 | 0 |
| 9093 | 0 | 45 | 0 | 0 | 47 | 0 | 0 | 8 | 0 |
| 5748 | 0 | 41 | 0 | 1 | 44 | 1 | 0 | 8 | 0 |
| 10233 | 0 | 53 | 0 | 0 | 55 | 1 | 1 | 11 | 0 |
| 10176 | 0 | 50 | 0 | 1 | 52 | 0 | 1 | 10 | 0 |
| 10050 | 0 | 46 | 0 | 0 | 50 | 0 | 0 | 10 | 0 |
| 10791 | 1 | 55 | 1 | 1 | 56 | 1 | 0 | 8 | 0 |
| 10354 | 0 | 43 | 0 | 1 | 51 | 1 | 0 | 7 | 0 |
| 10553 | 0 | 46 | 0 | 0 | 51 | 0 | 0 | 11 | 0 |
| 10788 | 0 | 53 | 0 | 0 | 55 | 0 | 0 | 6 | 0 |

| No. | Unassisted Open | | | Assisted Open | | | R Laterotrusion | | |
|---|---|---|---|---|---|---|---|---|---|
| | L pain | mm | R pain | L pain | mm | R pain | L pain | mm | R pain |
| 10399 | 0 | 60 | 0 | 0 | 60 | 0 | 0 | 9 | 0 |
| 10485 | 0 | 44 | 1 | 2 | 55 | 2 | 1 | 8 | 0 |
| 10554 | 0 | 52 | 0 | 1 | 58 | 0 | 0 | 10 | 0 |
| 6796 | 0 | 56 | 0 | 0 | 56 | 0 | 0 | 8 | 0 |
| 10671 | 1 | 53 | 1 | 1 | 53 | 1 | 0 | 6 | 0 |
| 10736 | 0 | 55 | 0 | 0 | 55 | 0 | 1 | 11 | 0 |
| 4703 | n | n | n | n | n | n | n | n | n |
| 10666 | 0 | 51 | 0 | 0 | 52 | 0 | 0 | 10 | 0 |
| 9985 | 0 | 42 | 0 | 0 | 44 | 0 | 0 | 8 | 0 |
| 9344 | 0 | 41 | 0 | 0 | 48 | 0 | 0 | 6 | 0 |
| 10639 | 0 | 55 | 0 | 0 | 58 | 0 | 0 | 12 | 0 |
| 4381 | 1 | 47 | 0 | 1 | 51 | 0 | 0 | 5 | 0 |
| 9411 | 0 | 56 | 0 | 0 | 57 | 1 | 0 | 9 | 0 |
| 10670 | 0 | 68 | 0 | 0 | 69 | 0 | 0 | 12 | 0 |
| 9161 | 0 | 57 | 0 | 0 | 58 | 0 | 0 | 10 | 0 |
| 10638 | 0 | 52 | 0 | 0 | 58 | 1 | 0 | 10 | 0 |
| 9244 | 0 | 50 | 0 | 0 | 50 | 0 | 0 | 8 | 0 |
| 10646 | 0 | 50 | 0 | 0 | 53 | 0 | 0 | 8 | 0 |
| 10645 | 0 | 51 | 1 | 0 | 52 | 1 | 0 | 11 | 1 |
| 4005 | 0 | 60 | 0 | 0 | 61 | 1 | 0 | 10 | 0 |
| 11440 | 0 | 59 | 0 | 0 | 60 | 0 | 0 | 9 | 0 |
| 10555 | 0 | 52 | 0 | 0 | 52 | 0 | 0 | 8 | 0 |
| 11108 | 0 | 50 | 0 | 0 | 52 | 0 | 0 | 11 | 0 |
| 9124 | 0 | 54 | 0 | 0 | 54 | 0 | 0 | 10 | 0 |
| 10423 | 0 | 54 | 0 | 0 | 56 | 0 | 0 | 10 | 0 |
| 10837 | 0 | 57 | 0 | 0 | 61 | 0 | 0 | 12 | 0 |
| 11075 | 0 | 42 | 0 | 1 | 47 | 0 | 0 | 10 | 0 |
| 9382 | 0 | 60 | 0 | 0 | 60 | 0 | 0 | 12 | 0 |
| 11146 | 0 | 54 | 0 | 0 | 55 | 0 | 0 | 14 | 0 |
| 10626 | 1 | 60 | 0 | 0 | 61 | 0 | 0 | 12 | 0 |
| 9163 | 0 | 57 | 0 | 0 | 58 | 0 | 0 | 13 | 0 |
| 10667 | 0 | 47 | 0 | 0 | 58 | 1 | 0 | 10 | 0 |
| 9274 | 0 | 59 | 0 | 0 | 64 | 0 | 0 | 10 | 0 |
| 6429 | 0 | 55 | 0 | 0 | 59 | 0 | 0 | 6 | 0 |
| 10877 | 0 | 57 | 0 | 0 | 58 | 0 | 0 | 7 | 0 |
| 10879 | 0 | 60 | 0 | 0 | 62 | 0 | 0 | 11 | 0 |
| 10740 | 0 | 51 | 0 | 0 | 54 | 0 | 0 | 10 | 0 |
| 10133 | 0 | 35 | 0 | 0 | 36 | 0 | 0 | 3 | 0 |
| 10989 | 0 | 50 | 0 | 0 | 55 | 0 | 0 | 9 | 0 |

| No. | Unassisted Open | | | Assisted Open | | | R Laterotrusion | | |
|---|---|---|---|---|---|---|---|---|---|
| | L pain | mm | R pain | L pain | mm | R pain | L pain | mm | R pain |
| 5105 | 0 | 60 | 0 | 0 | 64 | 0 | 0 | 12 | 0 |
| 10047 | 0 | 61 | 0 | 0 | 64 | 0 | 0 | 12 | 0 |
| 10517 | 1 | 51 | 1 | 1 | 52 | 1 | 0 | 10 | 0 |
| 7749 | 0 | 44 | 0 | 0 | 49 | 0 | 0 | 9 | 0 |
| 9702 | 1 | 44 | 0 | 1 | 45 | 0 | n | n | n |
| 9092 | n | n | n | n | n | n | n | n | n |
| 11048 | 0 | 52 | 0 | 0 | 53 | 0 | 0 | 10 | 0 |
| 10640 | 0 | 60 | 0 | 1 | 60 | 1 | 0 | 9 | 0 |
| 10840 | 0 | 47 | 0 | 0 | 49 | 0 | 0 | 9 | 0 |
| 10647 | 0 | 52 | 0 | 0 | 53 | 0 | 0 | 7 | 0 |
| 9479 | 0 | 60 | 0 | 0 | 60 | 0 | 0 | 14 | 0 |
| 10720 | 1 | 59 | 0 | 1 | 60 | 1 | 0 | 13 | 0 |
| 10282 | 0 | 48 | 0 | 0 | 50 | 0 | 1 | 11 | 0 |
| 9284 | 1 | 49 | 1 | 1 | 50 | 1 | 0 | 10 | 0 |
| 10737 | 0 | 60 | 0 | 0 | 60 | 0 | 0 | 8 | 0 |
| 10839 | 0 | 47 | 0 | 0 | 49 | 0 | 0 | 12 | 0 |
| 11004 | 0 | 55 | 0 | 0 | 55 | 0 | 0 | 10 | 0 |
| 10071 | 0 | 54 | 0 | 0 | 55 | 0 | 0 | 10 | 0 |
| 9340 | 0 | 55 | 0 | 0 | 56 | 0 | 0 | 12 | 0 |
| 10627 | 0 | 59 | 0 | 0 | 59 | 0 | 0 | 10 | 0 |
| 9873 | 0 | 53 | 0 | 1 | 54 | 1 | 0 | 10 | 0 |
| 9347 | 0 | 44 | 0 | 0 | 44 | 1 | 0 | 9 | 0 |
| 10174 | 1 | 50 | 1 | 1 | 52 | 1 | 1 | 11 | 0 |
| 9128 | 0 | 53 | 0 | 0 | 54 | 0 | 0 | 11 | 0 |
| 10284 | 0 | 60 | 0 | 0 | 61 | 0 | 1 | 10 | 0 |
| 9164 | 0 | 45 | 0 | 0 | 47 | 0 | 0 | 7 | 0 |
| 9125 | 0 | 49 | 0 | 0 | 51 | 0 | 0 | 10 | 0 |
| 10112 | 0 | 53 | 0 | 0 | 55 | 0 | 0 | 8 | 0 |
| 9088 | 0 | 45 | 0 | 0 | 46 | 0 | 0 | 10 | 0 |
| 10833 | 1 | 45 | 1 | 1 | 46 | 1 | 1 | 9 | 0 |
| 9910 | 0 | 42 | 0 | 1 | 46 | 1 | 1 | 6 | 0 |
| 9162 | 0 | 40 | 0 | 0 | 45 | 0 | 0 | 9 | 0 |
| 9062 | 0 | 40 | 0 | n | n | n | n | n | n |
| 10254 | 0 | 48 | 0 | 0 | 49 | 0 | 0 | 9 | 0 |
| 10998 | 0 | 52 | 0 | 0 | 59 | 0 | 0 | 10 | 0 |
| 10589 | 0 | 55 | 0 | 0 | 57 | 0 | 1 | 12 | 0 |
| 10048 | 0 | 55 | 0 | 0 | 59 | 0 | 0 | 13 | 0 |
| 10919 | 0 | 49 | 0 | 0 | 49 | 0 | 0 | 11 | 0 |
| 10571 | 0 | 64 | 0 | 0 | 65 | 0 | 0 | 8 | 0 |

| No. | Unassisted Open | | | Assisted Open | | | R Laterotrusion | | |
|---|---|---|---|---|---|---|---|---|---|
| | L pain | mm | R pain | L pain | mm | R pain | L pain | mm | R pain |
| 11080 | 0 | 58 | 0 | 0 | 58 | 0 | 0 | 8 | 0 |
| 10643 | 0 | 45 | 0 | 0 | 45 | 0 | 1 | 6 | 0 |
| 10447 | 0 | 37 | 0 | 1 | 40 | 0 | 0 | 9 | 0 |
| 11077 | 1 | 47 | 0 | 1 | 47 | 0 | 0 | 9 | 0 |
| 10141 | 0 | 45 | 0 | 0 | 46 | 0 | 0 | 8 | 0 |
| 10732 | 0 | 61 | 0 | 0 | 61 | 0 | 0 | 9 | 0 |
| 10315 | 0 | 53 | 0 | 0 | 55 | 0 | 0 | 8 | 0 |
| 10629 | 1 | 55 | 1 | 1 | 56 | 0 | 0 | 8 | 0 |
| 9606 | 0 | 43 | 0 | 0 | 50 | 0 | 0 | 10 | 0 |
| 10344 | 0 | 59 | 0 | 0 | 59 | 0 | 0 | 10 | 0 |
| 9733 | 0 | 42 | 0 | 0 | 43 | 0 | 0 | 11 | 1 |
| 9202 | 1 | 40 | 0 | 1 | 41 | 0 | 0 | 9 | 0 |
| 10445 | 0 | 50 | 0 | 0 | 51 | 1 | 0 | 9 | 0 |
| 9650 | 0 | 35 | 1 | 0 | 37 | 1 | 0 | 7 | 0 |
| 11336 | 0 | 43 | 1 | 0 | 47 | 1 | 0 | 6 | 1 |

## Appendix 9(c)

## Clinical Signs and Symptoms Continued

**Key:**

| | |
|---|---|
| Deviation | deviation of the mandibular midline on mouth opening to Left or Right in mm |
| n | no reponse noted for clinical variable |
| L pain | Left sided pain experienced on jaw movement |
| R pain | Right sided pain experienced on jaw movement |
| mm | millimetre measurement of mandibular movement |

| No. | | L Laterotrusion | | Protrusive | | | Deviation | |
|---|---|---|---|---|---|---|---|---|
| | L pain | mm | R pain | L pain | mm | R pain | L | R |
| 10631 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10734 | 0 | 10 | 1 | 0 | 9 | 0 | 0 | 0 |
| 9309 | 0 | 11 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10140 | 1 | 10 | 1 | 0 | 10 | 0 | 0 | 0 |
| 10716 | 0 | 12 | 0 | 1 | 11 | 1 | 0 | 0 |
| 10962 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 7767 | 0 | 8 | 0 | 0 | 10 | 0 | 0 | 0 |
| 9938 | 0 | 12 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10569 | 0 | 9 | 0 | 0 | 11 | 0 | 0 | 0 |
| 10794 | 0 | 13 | 0 | 0 | 6 | 0 | 0 | 0 |
| 10495 | 0 | 11 | 1 | 0 | 8 | 0 | 1 | 0 |
| 9247 | 0 | 11 | 1 | 0 | 10 | 0 | 0 | 0 |
| 9559 | 0 | 10 | 0 | 0 | 10 | 0 | 1 | 0 |
| 10110 | 0 | 9 | 0 | 0 | 8 | 0 | 0 | 2 |
| 10491 | 0 | 9 | 0 | 0 | 10 | 0 | 0 | 0 |
| 9467 | 0 | 12 | 0 | 0 | 9 | 0 | 1 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 9 | 0 | 0 | 9 | 0 | 0 | 2 |
| 9700 | 0 | 11 | 0 | 0 | 13 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 0 | 9 | 0 | 1 | 8 | 0 | 0 | 0 |
| 10713 | 0 | 8 | 0 | 0 | 8 | 0 | 0 | 0 |
| 9129 | 0 | 10 | 0 | 0 | 11 | 0 | 0 | 0 |
| 9713 | 0 | 12 | 1 | 1 | 10 | 1 | 0 | 2 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 0 |
| 10576 | 0 | 7 | 1 | 0 | 8 | 1 | 0 | 0 |

| No. |  | L Laterotrusion |  | Protrusive |  |  | Deviation |  |
|---|---|---|---|---|---|---|---|---|
|  | L pain | mm | R pain | L pain | mm | R pain | L | R |
| 9273 | 0 | 10 | 0 | 0 | 9 | 0 | 0 | 0 |
| 10574 | 0 | 8 | 0 | 0 | 10 | 0 | 0 | 0 |
| 9945 | 0 | 14 | 0 | 0 | 10 | 0 | 1 | 0 |
| 10741 | 0 | 11 | 0 | 0 | 9 | 0 | 0 | 2 |
| 10568 | 0 | 8 | 0 | 0 | 11 | 0 | 0 | 2 |
| 10960 | 0 | 10 | 0 | 0 | 7 | 0 | 0 | 0 |
| 10596 | 0 | 12 | 0 | 1 | 12 | 0 | 0 | 0 |
| 6229 | 0 | 7 | 0 | 0 | 12 | 0 | 0 | 0 |
| 9872 | 1 | 7 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10642 | 0 | 9 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10549 | 0 | 11 | 0 | 0 | 9 | 0 | 0 | 0 |
| 11111 | 0 | 9 | 0 | 0 | 10 | 0 | 0 | 0 |
| 9903 | 0 | 11 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10959 | 0 | 12 | 0 | 0 | 12 | 1 | 0 | 0 |
| 10714 | 0 | 8 | 0 | 0 | 10 | 0 | 1 | 0 |
| 10878 | 0 | 8 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10969 | 0 | 9 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10793 | 0 | 10 | 0 | 0 | 7 | 0 | 0 | 0 |
| 10573 | 0 | 11 | 0 | 0 | 2 | 0 | 0 | 2 |
| 20000 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 9984 | 0 | 10 | 0 | 0 | 9 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 10 | 0 | 0 | 12 | 0 | 0 | 1 |
| 10572 | 0 | 9 | 0 | 1 | 10 | 1 | 0 | 0 |
| 10595 | 0 | 8 | 0 | 0 | 7 | 0 | 0 | 0 |
| 9087 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10882 | 0 | 10 | 0 | 0 | 9 | 0 | 0 | 0 |
| 9919 | 0 | 12 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10346 | 0 | 10 | 1 | 0 | 9 | 0 | 0 | 2 |
| 9064 | 0 | 8 | 0 | 0 | 9 | 0 | 0 | 0 |
| 10733 | 0 | 10 | 0 | 0 | 12 | 0 | 0 | 0 |
| 9093 | 0 | 8 | 0 | 0 | 8 | 0 | 0 | 0 |
| 5748 | 0 | 6 | 0 | 0 | 12 | 0 | 0 | 0 |
| 10233 | 0 | 7 | 1 | 0 | 8 | 0 | 0 | 1 |
| 10176 | 0 | 9 | 0 | 1 | 9 | 0 | 0 | 0 |
| 10050 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10791 | 0 | 12 | 0 | 1 | 13 | 1 | 0 | 0 |
| 10354 | 0 | 7 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10553 | 0 | 10 | 0 | 0 | 9 | 0 | 0 | 0 |
| 10788 | 0 | 10 | 0 | 0 | 8 | 0 | 2 | 0 |

| No. | | L Laterotrusion | | Protrusive | | | Deviation | |
|---|---|---|---|---|---|---|---|---|
| | L pain | mm | R pain | L pain | mm | R pain | L | R |
| 10399 | 0 | 7 | 0 | 0 | 7 | 0 | 0 | 0 |
| 10485 | 0 | 8 | 1 | 0 | 8 | 0 | 0 | 0 |
| 10554 | 0 | 9 | 0 | 0 | 11 | 0 | 0 | 0 |
| 6796 | 0 | 7 | 0 | 0 | 9 | 0 | 0 | 0 |
| 10671 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10736 | 0 | 12 | 0 | 0 | 12 | 0 | 0 | 0 |
| 4703 | n | n | n | n | n | n | n | n |
| 10666 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 9985 | 0 | 8 | 0 | 0 | 8 | 0 | 0 | 1 |
| 9344 | 0 | 5 | 0 | 0 | 5 | 0 | 1 | 0 |
| 10639 | 0 | 12 | 0 | 0 | 15 | 0 | 0 | 0 |
| 4381 | 0 | 5 | 0 | 0 | 10 | 0 | 0 | 3 |
| 9411 | 0 | 10 | 0 | 0 | 10 | 1 | 0 | 0 |
| 10670 | 0 | 12 | 0 | 0 | 9 | 0 | 0 | 0 |
| 9161 | 0 | 10 | 1 | 0 | 7 | 0 | 0 | 0 |
| 10638 | 0 | 10 | 1 | 1 | 9 | 0 | 0 | 0 |
| 9244 | 0 | 6 | 0 | 0 | 9 | 0 | 0 | 1 |
| 10646 | 0 | 9 | 0 | 8 | 0 | 0 | 0 | 0 |
| 10645 | 0 | 13 | 0 | 0 | 8 | 1 | 0 | 0 |
| 4005 | 0 | 9 | 0 | 0 | 11 | 0 | 0 | 0 |
| 11440 | 0 | 7 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10555 | 0 | 8 | 0 | 0 | 7 | 0 | 0 | 0 |
| 11108 | 0 | 11 | 0 | 0 | 10 | 0 | 2 | 0 |
| 9124 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10423 | 0 | 12 | 0 | 0 | 7 | 0 | 0 | 0 |
| 10837 | 0 | 10 | 0 | 0 | 10 | 0 | 0 | 0 |
| 11075 | 0 | 9 | 0 | 0 | 8 | 0 | 1 | 0 |
| 9382 | 0 | 12 | 0 | 0 | 10 | 0 | 0 | 0 |
| 11146 | 0 | 11 | 0 | 0 | 15 | 0 | 0 | 0 |
| 10626 | 0 | 12 | 0 | 0 | 13 | 0 | 0 | 0 |
| 9163 | 0 | 13 | 0 | 0 | 13 | 0 | 0 | 0 |
| 10667 | 0 | 10 | 0 | 0 | 10 | 0 | 0 | 0 |
| 9274 | 0 | 10 | 0 | 0 | 11 | 0 | 0 | 0 |
| 6429 | 0 | 10 | 0 | 0 | 11 | 0 | 0 | 0 |
| 10877 | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 0 |
| 10879 | 0 | 11 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10740 | 0 | 9 | 0 | 0 | 7 | 0 | 0 | 0 |
| 10133 | 0 | 6 | 0 | 0 | 5 | 0 | 7 | 0 |
| 10989 | 0 | 9 | 0 | 0 | 9 | 0 | 0 | 0 |
| 5105 | 0 | 13 | 0 | 0 | 9 | 0 | 0 | 0 |

| No. | | L Laterotrusion | | Protrusive | | | Deviation | |
|---|---|---|---|---|---|---|---|---|
| | L pain | mm | R pain | L pain | mm | R pain | L | R |
| 10047 | 0 | 11 | 0 | 0 | 13 | 0 | 0 | 0 |
| 10517 | 0 | 10 | 0 | 0 | 11 | 0 | 0 | 0 |
| 7749 | 0 | 10 | 0 | 0 | 11 | 0 | 0 | 0 |
| 9702 | 0 | 8 | 0 | 0 | 10 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |
| 11048 | 0 | 11 | 0 | 0 | 10 | 0 | 0 | 2 |
| 10640 | 0 | 8 | 0 | 0 | 11 | 0 | 0 | 0 |
| 10840 | 0 | 9 | 0 | 0 | 9 | 0 | 0 | 0 |
| 10647 | 0 | 8 | 0 | 0 | 8 | 0 | 0 | 0 |
| 9479 | 0 | 12 | 0 | 0 | 13 | 0 | 0 | 0 |
| 10720 | 0 | 13 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10282 | 0 | 11 | 0 | 0 | 9 | 1 | 0 | 0 |
| 9284 | 0 | 10 | 1 | 0 | 12 | 0 | 0 | 1 |
| 10737 | 0 | 8 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10839 | 0 | 11 | 0 | 0 | 12 | 0 | 0 | 0 |
| 11004 | 0 | 10 | 0 | 0 | 11 | 0 | 0 | 0 |
| 10071 | 0 | 10 | 0 | 0 | 11 | 0 | 0 | 0 |
| 9340 | 0 | 13 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10627 | 0 | 11 | 0 | 0 | 11 | 0 | 0 | 0 |
| 9873 | 0 | 10 | 0 | 0 | 7 | 0 | 0 | 0 |
| 9347 | 0 | 11 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10174 | 0 | 10 | 1 | 1 | 9 | 1 | 2 | 0 |
| 9128 | 0 | 11 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10284 | 0 | 12 | 1 | 0 | 12 | 0 | 0 | 0 |
| 9164 | 0 | 7 | 0 | 0 | 8 | 0 | 1 | 0 |
| 9125 | 0 | 10 | 0 | 0 | 7 | 0 | 0 | 0 |
| 10112 | 0 | 8 | 0 | 0 | 5 | 0 | 0 | 4 |
| 9088 | 0 | 12 | 0 | 0 | 9 | 0 | 0 | 0 |
| 10833 | 0 | 10 | 1 | 1 | 10 | 1 | 0 | 2 |
| 9910 | 0 | 10 | 1 | 1 | 7 | 0 | 0 | 0 |
| 9162 | 0 | 8 | 0 | 0 | 6 | 0 | 0 | 1 |
| 9062 | n | n | n | n | n | n | n | n |
| 10254 | 0 | 8 | 0 | 0 | 7 | 0 | 0 | 0 |
| 10998 | 0 | 8 | 0 | 0 | 8 | 0 | 0 | 0 |
| 10589 | 0 | 15 | 0 | 0 | 11 | 0 | 0 | 0 |
| 10048 | 0 | 10 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10919 | 0 | 9 | 0 | 0 | 9 | 0 | 0 | 0 |
| 10571 | 0 | 9 | 0 | 0 | 8 | 0 | 0 | 0 |
| 11080 | 0 | 10 | 0 | 0 | 6 | 0 | 0 | 0 |
| 10643 | 0 | 7 | 0 | 0 | 11 | 0 | 0 | 0 |

| No. | | L Laterotrusion | | Protrusive | | | Deviation | |
|---|---|---|---|---|---|---|---|---|
| | L pain | mm | R pain | L pain | mm | R pain | L | R |
| 10447 | 0 | 12 | 0 | 0 | 8 | 0 | 4 | 0 |
| 11077 | 0 | 8 | 0 | 1 | 7 | 0 | 0 | 0 |
| 10141 | 0 | 8 | 0 | 0 | 7 | 0 | 0 | 2 |
| 10732 | 0 | 9 | 0 | 0 | 10 | 0 | 0 | 2 |
| 10315 | 0 | 10 | 0 | 0 | 8 | 0 | 2 | 0 |
| 10629 | 0 | 10 | 0 | 0 | 11 | 0 | 2 | 0 |
| 9606 | 0 | 11 | 0 | 0 | 10 | 0 | 0 | 0 |
| 10344 | 0 | 11 | 0 | 0 | 8 | 0 | 0 | 0 |
| 9733 | 0 | 10 | 0 | 0 | 9 | 0 | 0 | 0 |
| 9202 | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 0 |
| 10445 | 0 | 10 | 0 | 0 | 8 | 0 | 0 | 0 |
| 9650 | 0 | 7 | 1 | 0 | 6 | 1 | 0 | 0 |
| 11336 | 0 | 9 | 0 | 0 | 10 | 0 | n | n |

## Appendix 9(d)

## Clinical Signs and Symptoms Continued

**Key:**

| | |
|---|---|
| CR/CO | discrepancy between centric relation and centric occlusion mandibular position |
| anterior | CR/CO discrepancy in anterior direction measured in mm |
| vertical | CR/CO discrepancy in vertical direction measured in mm |
| lateral | CR/CO discrepancy in lateral direction measured in mm |
| L to R | CR/CO deviation from Left to Right 0 - absent; 1 - present |
| Dental Relationship | Left and Right side Angle molar relationship; Class I =1, Class II = 2, Class III = 3 |

| No. | CR/CO Discrepancy | | | CR/CO Deviation | | Dental Relationship | |
|---|---|---|---|---|---|---|---|
| | anterior | vertical | lateral | L to R | R to L | L | R |
| 10631 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10734 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 9309 | n | n | n | n | n | n | n |
| 10140 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10716 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10962 | 0 | 2 | 2 | 0 | 0 | 1 | 1 |
| 7767 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 10495 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 9247 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 9559 | 2 | 1 | 1 | 0 | 1 | n | n |
| 10110 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| 10491 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 9467 | 0 | 1 | 0 | 0 | 0 | n | n |
| 10570 | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9700 | 1 | 2 | 1 | 0 | 1 | 1 | 1 |
| 10369 | n | n | n | n | n | n | n |
| 10392 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10713 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| 9129 | n | n | n | n | n | n | n |
| 9713 | 2 | 2 | 2 | 1 | 0 | 2 | 2 |
| 7702 | n | n | n | n | n | n | n |

| No. | CR/CO Discrepancy | | | CR/CO Deviation | | Dental Relationship | |
|---|---|---|---|---|---|---|---|
| | anterior | vertical | lateral | L to R | R to L | L | R |
| 10575 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10576 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9273 | n | n | n | n | n | 1 | 1 |
| 10574 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9945 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 10741 | 0 | 2 | 2 | 1 | 0 | 1 | 1 |
| 10568 | 1 | 2 | 2 | 0 | 1 | 1 | 1 |
| 10960 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| 10596 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 6229 | 0 | 0 | 2 | 0 | 1 | 2 | 2 |
| 9872 | 0 | 1 | 0 | 0 | 0 | 3 | 3 |
| 10642 | 0 | 0 | 2 | 0 | 1 | 1 | 1 |
| 10549 | 1 | 1 | 0 | 0 | 0 | 2 | 2 |
| 11111 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| 9903 | 1 | 3 | 4 | 0 | 1 | 1 | 1 |
| 10959 | 0 | 1 | 1 | 1 | 0 | 2 | 1 |
| 10714 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10878 | 1 | 1 | 0 | 0 | 0 | 1 | 2 |
| 10969 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| 10793 | 0 | 0 | 1 | 0 | 1 | 2 | 2 |
| 10573 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 20000 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9984 | 2 | 0 | 0 | n | n | 1 | 1 |
| 7703 | n | n | n | n | n | n | n |
| 9988 | 1 | 0 | 0 | 0 | 0 | 2 | 2 |
| 10572 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 10595 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9087 | n | n | n | n | n | 1 | 1 |
| 10882 | 0 | 1 | 1 | 0 | 1 | 2 | 1 |
| 9919 | 2 | 2 | 2 | 1 | 0 | 1 | 1 |
| 10346 | 2 | 3 | 3 | 0 | 1 | 1 | 1 |
| 9064 | n | n | n | n | n | 2 | 2 |
| 10733 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9093 | 0 | 0 | 1 | 0 | 0 | n | n |
| 5748 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10233 | 0 | 2 | 2 | 0 | 1 | 2 | 2 |
| 10176 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| 10050 | 0 | 1 | 2 | 0 | 1 | 2 | 2 |
| 10791 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

| No. | CR/CO Discrepancy |  |  | CR/CO Deviation |  | Dental Relationship |  |
|---|---|---|---|---|---|---|---|
|  | anterior | vertical | lateral | L to R | R to L | L | R |
| 10553 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| 10788 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10485 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10554 | 1 | 2 | 0 | 0 | 0 | 1 | 1 |
| 6796 | 0 | 1 | 0 | 0 | 0 | 2 | 1 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10736 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| 4703 | n | n | n | n | n | n | n |
| 10666 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 9985 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9344 | 0 | 1 | 0 | 0 | 0 | n | n |
| 10639 | 0 | 1 | 1 | 0 | 1 | 2 | 2 |
| 4381 | 2 | 1 | 1 | 0 | 1 | 2 | 2 |
| 9411 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10670 | 1 | 2 | 0 | 0 | 0 | 2 | 2 |
| 9161 | n | n | n | n | n | n | n |
| 10638 | 2 | 1 | 0 | 0 | 0 | 2 | 2 |
| 9244 | n | n | n | n | n | 2 | 2 |
| 10646 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10645 | 1 | 1 | 0 | 0 | 0 | 2 | 2 |
| 4005 | 1 | 1 | 1 | 0 | 1 | n | n |
| 11440 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 11108 | 1 | 1 | 1 | 1 | 0 | 2 | 2 |
| 9124 | n | n | n | n | n | n | n |
| 10423 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10837 | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| 11075 | 0 | 1 | 1 | 0 | 1 | 2 | 2 |
| 9382 | 1 | 2 | 0 | 0 | 0 | 1 | 1 |
| 11146 | 1 | 1 | 2 | 0 | 1 | 2 | 2 |
| 10626 | 1 | 0 | 1 | 1 | 0 | 2 | 2 |
| 9163 | 1 | 2 | 0 | 0 | 0 | 2 | 2 |
| 10667 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9274 | n | n | n | n | n | 2 | 2 |
| 6429 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10877 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 10879 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 10740 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |

| No. | CR/CO Discrepancy |  |  | CR/CO Deviation |  | Dental Relationship |  |
|---|---|---|---|---|---|---|---|
|  | anterior | vertical | lateral | L to R | R to L | L | R |
| 10989 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| 5105 | 1 | 2 | 2 | 0 | 1 | 1 | 1 |
| 10047 | 1 | 1 | 2 | 0 | 1 | 2 | 2 |
| 10517 | 1 | 2 | 1 | 1 | 0 | 1 | 2 |
| 7749 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| 9702 | 0 | 0 | 1 | 1 | 0 | 2 | 2 |
| 9092 | n | n | n | n | n | n | n |
| 11048 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 10640 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10647 | 1 | 0 | 0 | 0 | 0 | 2 | 2 |
| 9479 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10720 | 2 | 0 | 0 | 1 | 0 | 1 | 1 |
| 10282 | 0 | 0 | 2 | 1 | 0 | 1 | 1 |
| 9284 | 1 | 1 | 0 | 0 | 0 | 2 | 2 |
| 10737 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 11004 | 1 | 1 | 0 | 0 | 0 | 1 | 2 |
| 10071 | 1 | 1 | 1 | 1 | 0 | 2 | 1 |
| 9340 | 1 | 2 | 1 | 1 | 0 | 1 | 2 |
| 10627 | 1 | 4 | 0 | 0 | 0 | 1 | 1 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9347 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10174 | 1 | 1 | 1 | 1 | 0 | 2 | 2 |
| 9128 | n | n | n | n | n | 2 | 2 |
| 10284 | 1 | 2 | 0 | 0 | 0 | 3 | 3 |
| 9164 | 0 | 0 | 0 | 0 | 0 | n | n |
| 9125 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 10112 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9088 | n | n | n | n | n | 1 | 1 |
| 10833 | 1 | 1 | 1 | 0 | 1 | 2 | 2 |
| 9910 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 9162 | 1 | 3 | 0 | 0 | 0 | n | n |
| 9062 | n | n | n | n | n | n | n |
| 10254 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 10998 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 10589 | 0 | 0 | 1 | 1 | 0 | 2 | 2 |
| 10048 | 0 | 1 | 1 | 0 | 1 | 2 | 2 |
| 10919 | 0 | 2 | 0 | 0 | 0 | 1 | 2 |
| 10571 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |

| No. | CR/CO Discrepancy<br>anterior | vertical | lateral | CR/CO Deviation<br>L to R | R to L | Dental Relationship<br>L | R |
|---|---|---|---|---|---|---|---|
| 11080 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| 10643 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10447 | 1 | 0 | 0 | 0 | 0 | 2 | 2 |
| 11077 | 1 | 2 | 2 | 0 | 1 | 1 | 1 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10732 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10315 | 0 | 2 | 0 | 0 | 0 | 2 | 2 |
| 10629 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 9606 | 1 | 1 | 0 | 0 | 0 | 2 | 2 |
| 10344 | 0 | 1 | 0 | 0 | 0 | 2 | 1 |
| 9733 | 0 | 0 | 0 | 0 | 0 | n | n |
| 9202 | 0 | 1 | 0 | 0 | 0 | n | n |
| 10445 | 0 | 0 | 1 | 0 | 1 | 3 | 3 |
| 9650 | 2 | 0 | 0 | 0 | 0 | 2 | 2 |
| 11336.00 | 0 | 0 | 1 | 0 | 1 | 2 | 2 |

## Appendix 9(e)

## Clinical Signs and Symptoms Continued

**Key:**

Score 0 - no joint sound detected; 1- joint sound present

| No. | Reproducible Joint Clicking | | | | Nonreproducible Joint Clicking | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10716 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 10962 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10495 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10110 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10713 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9945 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

| No. | Reproducible Joint Clicking | | | | Nonreproducible Joint Clicking | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10741 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10596 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 6229 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9872 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9984 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10572 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10595 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9064 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10233 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10176 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 10050 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10399 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

| No. | Reproducible Joint Clicking | | | | Nonreproducible Joint Clicking | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 4703 | n | n | n | n | n | n | n | n |
| 10666 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9985 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 4381 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10670 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9244 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11440 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10626 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9274 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6429 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10740 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 5105 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Reproducible Joint Clicking | | | | Nonreproducible Joint Clicking | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10517 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |
| 11048 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10640 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9479 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10282 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10112 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9910 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10589 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 10571 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11080 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Reproducible Joint Clicking | | | | Nonreproducible Joint Clicking | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10447 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11077 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10732 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10315 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9606 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11336 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

## Appendix 9(f)

## Clinical Signs and Symptoms Continued

| No | Early Joint Sounds |  |  |  | Mid-Range Joint Sounds |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10716 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10962 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10495 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10713 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9945 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 10960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10596 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

| No | Early Joint Sounds |  |  |  | Mid-Range Joint Sounds |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 6229 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9872 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10572 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10595 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9064 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10233 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10176 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10050 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10485 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 4703 | n | n | n | n | n | n | n | n |

| No | Early Joint Sounds |  |  |  | Mid-Range Joint Sounds |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9985 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10670 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11440 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10626 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 0 |  | 0 | 0 |
| 9274 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6429 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10740 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 5105 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10517 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |
| 11048 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10640 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No | Early Joint Sounds | | | | Mid-Range Joint Sounds | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9479 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10282 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10112 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9910 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10589 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10571 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11080 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11077 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10732 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9606 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No | Early Joint Sounds |  |  |  | Mid-Range Joint Sounds |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11336 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

## Appendix 9(g)

## Clinical Signs and Symptoms Continued

| No. | Late Joint Sounds | | | | Single Joint Sounds | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10716 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| 10962 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10495 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 10110 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 10713 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9945 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10741 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10568 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10596 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |

| No. | Late Joint Sounds | | | | Single Joint Sounds | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 6229 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9872 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 0 | n | 0 | 0 | 0 | 0 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 10572 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10595 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9064 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10233 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10176 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10050 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10485 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 4703 | n | n | n | n | n | n | n | n |

| No. | Late Joint Sounds | | | | Single Joint Sounds | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10666 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 9985 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 4381 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 9411 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10670 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9244 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 4005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11440 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 10626 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9274 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 6429 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 10740 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 5105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10517 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 9092 | n | n | n | n | n | n | n | n |
| 11048 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 10640 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Late Joint Sounds |  |  |  | Single Joint Sounds |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9479 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10282 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10112 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9910 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10589 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 10571 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11080 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11077 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10732 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10315 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10629 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9606 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

| No. | Late Joint Sounds | | | | Single Joint Sounds | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11336 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

## Appendix 9(h)

## Clinical Signs and Symptoms Continued

| No | Multiple Joint Sounds |  |  |  | Acute Joint Lock |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 10716 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10962 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10495 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10713 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9945 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10741 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10596 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No | Multiple Joint Sounds |  |  |  | Acute Joint Lock |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 6229 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9872 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10572 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10595 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9064 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10233 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10050 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4703 | n | n | n | n | n | n | n | n |

| No | Multiple Joint Sounds | | | | Acute Joint Lock | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9985 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10670 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 4005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11440 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10626 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9274 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6429 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10740 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5105 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10517 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |
| 11048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10640 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No | Multiple Joint Sounds | | | | Acute Joint Lock | | | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9479 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10282 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9910 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10589 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10571 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11080 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 11077 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10732 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9606 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |

| No | Multiple Joint Sounds |  |  |  | Acute Joint Lock |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R Open | R Close | L Open | L Close |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11336 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Appendix 9(i)

### Clinical Signs and Symptoms Continued

| No. | Chronic Joint Lock |  |  |  | Lateral Caps Pain |  | Posterior Caps Pain |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R | L | R | L |
| 10631 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10716 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10962 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10495 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10713 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 0 | n | n | n | n |
| 9945 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 10596 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 6229 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

| No. | Chronic Joint Lock |  |  |  | Lateral Caps Pain |  | Posterior Caps Pain |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R | L | R | L |
| 9872 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9903 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10959 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10878 | 0 | 0 | n | 0 | n | n | n | n |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 9984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 10572 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10595 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 9064 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10733 | 0 | 0 | 0 | 0 | n | n | n | n |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10233 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10050 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10788 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4703 | n | n | n | n | n | n | n | n |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Chronic Joint Lock | | | | Lateral Caps Pain | | Posterior Caps Pain | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R | L | R | L |
| 9985 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10670 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 4005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11440 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10837 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 11075 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 11146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10626 | 0 | 0 | 0 | 0 | n | n | n | n |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 9274 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 6429 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10740 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5105 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10047 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10517 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |
| 11048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10640 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Chronic Joint Lock |  |  |  | Lateral Caps Pain |  | Posterior Caps Pain |  |
|---|---|---|---|---|---|---|---|---|
|  | R Open | R Close | L Open | L Close | R | L | R | L |
| 10647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9479 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10282 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 9284 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10737 | 0 | 0 | 0 | 0 | n | n | n | n |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10112 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10833 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 9910 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10589 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10571 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 11080 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 11077 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10732 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | 0 | 0 | 0 | 0 | n | n | n | n |
| 9606 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Chronic Joint Lock | | | | Lateral Caps Pain | | Posterior Caps Pain | |
|---|---|---|---|---|---|---|---|---|
| | R Open | R Close | L Open | L Close | R | L | R | L |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 11336 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

## Appendix 9(j)

## Clinical Signs and Symptoms Continued

| No. | Super Caps Pain | | Fine Crepitus | | Coarse Crepitus | | Irregular Crepitus | |
|---|---|---|---|---|---|---|---|---|
| | R | L | R | L | R | L | R | L |
| 10631 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10716 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10962 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10495 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10713 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9273 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | n | n | 0 | 0 | 0 | 0 | 0 | 0 |
| 9945 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10596 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6229 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Super Caps Pain |  | Fine Crepitus |  | Coarse Crepitus |  | Irregular Crepitus |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 9872 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10878 | n | n | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10572 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10595 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9064 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10733 | n | n | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10233 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10050 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | n | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4703 | n | n | n | n | n | n | n | n |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Super Caps Pain |  | Fine Crepitus |  | Coarse Crepitus |  | Irregular Crepitus |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 9985 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10670 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4005 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 11440 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10626 | n | n | 0 | 0 | 0 | 0 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9274 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6429 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10740 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10517 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |
| 11048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10640 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Super Caps Pain | | Fine Crepitus | | Coarse Crepitus | | Irregular Crepitus | |
|---|---|---|---|---|---|---|---|---|
| | R | L | R | L | R | L | R | L |
| 10647 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 9479 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10282 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9284 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10737 | n | n | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10071 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10112 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9088 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9910 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10589 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10571 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11080 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11077 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10732 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | n | n | 0 | 0 | 0 | 0 | 0 | 0 |
| 9606 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10344 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Super Caps Pain | | Fine Crepitus | | Coarse Crepitus | | Irregular Crepitus | |
|---|---|---|---|---|---|---|---|---|
| | R | L | R | L | R | L | R | L |
| 9733 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 11336 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

# Appendix 9(k)

## Clinical Signs and Symptoms Continued

|  | Extraoral Musculature |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
| No. | ant. temporalis |  | middle temporalis |  | post. temporalis |  | deep masseter |  |
|  | R | L | R | L | R | L | R | L |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10716 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10962 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10495 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10713 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9945 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10596 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

| No. | Extraoral Musculature<br>ant. temporalis |  | middle temporalis |  | post. temporalis |  | deep masseter |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 6229 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9872 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9984 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10572 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 10595 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9064 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10233 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10176 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10050 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Extraoral Musculature

| No. | ant. temporalis |  | middle temporalis |  | post. temporalis |  | deep masseter |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 4703 | n | n | n | n | n | n | n | n |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9985 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10670 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 4005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11440 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10626 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 9274 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6429 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10740 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10517 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |

| No. | Extraoral Musculature<br>ant. temporalis |  | middle temporalis |  | post. temporalis |  | deep masseter |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 11048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10640 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9479 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10282 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 9284 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | n | n | n | n | n | n | n | n |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10112 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 9910 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10589 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10571 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11080 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11077 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10732 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Extraoral Musculature<br>ant. temporalis |  | middle temporalis |  | post. temporalis |  | deep masseter |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9606 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11336 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |

## Appendix 9(l).

## Clinical Signs and Symptoms Continued

| No. | Extra-oral Musculature<br>ant. masseter R | L | inf. masseter R | L | medial pterygoid R | L | post. digatric R | L |
|---|---|---|---|---|---|---|---|---|
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| 10716 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10962 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10495 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10713 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9945 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10596 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

| | Extra-oral Musculature | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| No. | ant. masseter | | inf. masseter | | medial pterygoid | | post. digatric | |
| | R | L | R | L | R | L | R | L |
| 6229 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9872 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10572 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10595 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9064 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10733 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 10233 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10176 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10050 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Extra-oral Musculature<br>ant. masseter R | ant. masseter L | inf. masseter R | inf. masseter L | medial pterygoid R | medial pterygoid L | post. digatric R | post. digatric L |
|---|---|---|---|---|---|---|---|---|
| 4703 | n | n | n | n | n | n | n | n |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9985 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9411 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10670 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4005 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 11440 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10626 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 9274 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6429 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10740 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10517 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 7749 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 9702 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |

Extra-oral Musculature

| No. | ant. masseter |  | inf. masseter |  | medial pterygoid |  | post. digatric |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 11048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10640 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9479 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10282 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9284 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | n | n | n | n | n | n | n | n |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10112 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| 9910 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10589 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10571 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 11080 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10643 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 10447 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 11077 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10141 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10732 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Extra-oral Musculature<br>ant. masseter R | L | inf. masseter R | L | medial pterygoid R | L | post. digatric R | L |
|---|---|---|---|---|---|---|---|---|
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9606 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11336 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

## Appendix 9(m)

## Clinical Signs and Symptoms Continued

| No. | Cervical Musculature<br>vertex |  | sup. sternocleido. |  | mid. sternocleido. |  | inf. sternocleido. |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10716 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10962 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10495 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9700 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n | n | n |
| 10392 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10713 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7702 | n | n | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9945 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 10568 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10596 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Cervical Musculature<br>vertex |  | sup. sternocleido. |  | mid. sternocleido. |  | inf. sternocleido. |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 6229 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9872 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n | n | n |
| 9988 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10572 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10595 | 0 | 0 | 1 | 1 | n | 0 | 0 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9064 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10233 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10050 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Cervical Musculature<br>vertex |  | sup. sternocleido. |  | mid. sternocleido. |  | inf. sternocleido. |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 4703 | n | n | n | n | n | n | n | n |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9985 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10670 | 0 | 0 | 0 | 0 |  | 0 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| 4005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11440 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10626 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 9274 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6429 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10740 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10517 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n | n | n |

Cervical Musculature

| No. | vertex | | sup. sternocleido. | | mid. sternocleido. | | inf. sternocleido. | |
|---|---|---|---|---|---|---|---|---|
| | R | L | R | L | R | L | R | L |
| 11048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10640 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9479 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10282 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | n | n | n | n | n | n | n | n |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9910 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10589 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10571 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11080 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11077 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10732 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Cervical Musculature<br>vertex |  | sup. sternocleido. |  | mid. sternocleido. |  | inf. sternocleido. |  |
|---|---|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L | R | L |
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9606 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11336 | 0 | 0 | n | n | n | n | n | n |

## Appendix 9(n)

## Clinical Signs and Symptoms Continued

|  | Cervical Musculature |  |  |  |  |  |
|---|---|---|---|---|---|---|
| No. | trap. insertion |  | upper trap. |  | splenius capitus |  |
|  | R | L | R | L | R | L |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10716 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10962 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10495 | 1 | 0 | 1 | 0 | 1 | 0 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n |
| 10392 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10713 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7702 | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 1 | 1 | 1 |
| 9945 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10596 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Cervical Musculature |  |  |  |  |  |
|---|---|---|---|---|---|---|
|  | trap. insertion |  | upper trap. |  | splenius capitus |  |
|  | R | L | R | L | R | L |
| 6229 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9872 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 0 | 1 | 0 | 1 |
| 9984 | 1 | 1 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n |
| 9988 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10572 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10595 | 1 | 1 | 0 | 0 | 1 | 1 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9064 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10733 | 0 | 1 | 0 | 1 | 0 | 1 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10233 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10176 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10050 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Cervical Musculature trap. insertion | | upper trap. | | splenius capitus | |
|---|---|---|---|---|---|---|
| | R | L | R | L | R | L |
| 4703 | n | n | n | n | n | n |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9985 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9344 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10670 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10646 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10645 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4005 | 1 | 1 | 1 | 1 | 0 | 0 |
| 11440 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11146 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10626 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9274 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6429 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10740 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10133 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5105 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10047 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10517 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7749 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9702 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n |

| No. | Cervical Musculature | | | | | |
|---|---|---|---|---|---|---|
| | trap. insertion | | upper trap. | | splenius capitus | |
| | R | L | R | L | R | L |
| 11048 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10640 | 0 | 0 | 1 | 1 | 1 | 1 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9479 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10720 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10282 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9284 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9347 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10174 | n | n | n | n | n | n |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10112 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 0 | 1 | 0 | 1 | 0 | 1 |
| 9910 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10589 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10571 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11080 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11077 | 1 | 1 | 0 | 0 | 1 | 0 |
| 10141 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10732 | 0 | 0 | 0 | 0 | 0 | 0 |

| No. | Cervical Musculature<br>trap. insertion R | L | upper trap. R | L | splenius capitus R | L |
|---|---|---|---|---|---|---|
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9606 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 2 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 0 | 1 | 0 | 1 | 0 | 1 |
| 11336 | n | n | n | n | n | n |

## Appendix 9(o)

## Clinical Signs and Symptoms Continued

| No. | Intraoral Musculature<br>temp. insertion |  | lat. pterygoid |  | medial pterygoid |  |
|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 1 | 1 | 1 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10140 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10716 | 1 | 1 | 1 | 1 | 1 | 0 |
| 10962 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7767 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9938 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 1 | 1 | 0 | 1 | 1 | 0 |
| 10495 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9247 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9559 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10110 | 1 | 0 | 1 | 0 | 0 | 0 |
| 10491 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9467 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10570 | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9700 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10369 | n | n | n | n | n | n |
| 10392 | n | n | n | n | n | n |
| 10713 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9129 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9713 | 1 | 1 | 1 | 1 | 1 | 0 |
| 7702 | n | n | n | n | n | n |
| 10575 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10576 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10574 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9945 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10568 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10960 | 1 | 0 | 1 | 0 | 1 | 1 |
| 10596 | 0 | 0 | 1 | 1 | 1 | 1 |

Intraoral Musculature

| No. | temp. insertion |  | lat. pterygoid |  | medial pterygoid |  |
|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L |
| 6229 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9872 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10642 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11111 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9903 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10959 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10714 | 1 | 0 | 1 | 1 | 0 | 0 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | n | n | n | n | n | n |
| 10573 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 0 | 1 | 0 | 0 | 1 |
| 9984 | 0 | 0 | 1 | 1 | 0 | 0 |
| 7703 | n | n | n | n | n | n |
| 9988 | 1 | 1 | 1 | 1 | 1 | 0 |
| 10572 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10595 | 1 | 0 | 1 | 1 | 0 | 0 |
| 9087 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10346 | n | n | n | n | n | n |
| 9064 | n | n | n | n | n | n |
| 10733 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9093 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5748 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10233 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10176 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10050 | 0 | 0 | 1 | 1 | 0 | 1 |
| 10791 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10788 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10485 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10671 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | n | 0 |

| No. | Intraoral Musculature | | | | | |
|---|---|---|---|---|---|---|
| | temp. insertion | | lat. pterygoid | | medial pterygoid | |
| | R | L | R | L | R | L |
| 4703 | n | n | n | n | n | n |
| 10666 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9985 | 1 | 1 | 1 | 1 | 0 | 0 |
| 9344 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10639 | 1 | 1 | 1 | 1 | 0 | 0 |
| 4381 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10670 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10638 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9244 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10646 | 1 | 0 | 1 | 0 | 0 | 0 |
| 10645 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4005 | 1 | 0 | 1 | 0 | 0 | 0 |
| 11440 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 1 | 1 | 1 | 1 | 0 |
| 9124 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10423 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10837 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11075 | 1 | 1 | 1 | 1 | 0 | 0 |
| 9382 | 1 | 1 | 0 | 0 | 0 | 0 |
| 11146 | 1 | 1 | 1 | 0 | 0 | 0 |
| 10626 | 1 | 1 | 1 | 1 | 0 | 0 |
| 9163 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10667 | n | n | n | n | n | n |
| 9274 | 0 | 0 | 1 | 1 | 0 | 0 |
| 6429 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10879 | 0 | 1 | 1 | 0 | 0 | 0 |
| 10740 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5105 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10047 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10517 | 0 | 0 | 1 | 1 | 0 | 0 |
| 7749 | 1 | 1 | 1 | 1 | 0 | 0 |
| 9702 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9092 | n | n | n | n | n | n |

| No. | Intraoral Musculature<br>temp. insertion |  | lat. pterygoid |  | medial pterygoid |  |
|---|---|---|---|---|---|---|
|  | R | L | R | L | R | L |
| 11048 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10640 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9479 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10720 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10282 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9284 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10737 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11004 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10627 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9873 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9347 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10174 | n | n | n | n | n | n |
| 9128 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10284 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9164 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9125 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10112 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9088 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10833 | 1 | 1 | 1 | 1 | 0 | 0 |
| 9910 | 1 | 1 | 1 | 1 | 1 | 0 |
| 9162 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9062 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10254 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10589 | 1 | 1 | 1 | 0 | 0 | 1 |
| 10048 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10919 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10571 | 1 | 1 | 0 | 1 | 1 | 1 |
| 11080 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10643 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10447 | 0 | 1 | 0 | 1 | 0 | 0 |
| 11077 | 1 | 0 | 1 | 1 | 1 | 1 |
| 10141 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10732 | 1 | 0 | 1 | 0 | 0 | 0 |

| No. | Intraoral Musculature<br>temp. insertion R | L | lat. pterygoid R | L | medial pterygoid R | L |
|---|---|---|---|---|---|---|
| 10315 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10629 | n | n | n | n | n | n |
| 9606 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10344 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9733 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10445 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9650 | 1 | 0 | 0 | 0 | 0 | 0 |
| 11336 | n | n | n | n | n | n |

## Appendix 9(p)

## Clinical Signs and Symptoms Continued

**Key:**

| | |
|---|---|
| A | TMJ pain history |
| B | TMJ sound history |
| C | Headache history |
| D | Neck pain history |
| E | Mouth Breathing habit |
| F | Tonsillectomy previously carried out |
| G | Digit Habit, present or recent previous history |

| | Subjective Findings | | | | | | |
|---|---|---|---|---|---|---|---|
| No. | A | B | C | D | E | F | G |
| 10631 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10734 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9309 | 0 | 0 | 0 | 0 | 0 | n | n |
| 10140 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 10716 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10962 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 7767 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| 9938 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10794 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10495 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 9247 | 0 | 0 | 1 | n | 0 | n | 1 |
| 9559 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10110 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| 10491 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9467 | n | n | n | n | n | n | n |
| 10570 | n | n | n | n | n | n | n |
| 10515 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 9700 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 10369 | n | n | n | n | n | n | n |
| 10392 | 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| 10713 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 9129 | 0 | n | 0 | n | 1 | n | n |
| 9713 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7702 | n | n | n | n | n | n | n |

| No. | Subjective Findings<br>A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 10575 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10576 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9273 | 0 | 0 | 0 | 0 | n | n | n |
| 10574 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9945 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10741 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10568 | n | 1 | 0 | 0 | 0 | 0 | 0 |
| 10960 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10596 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 6229 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 9872 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 10642 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 10549 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 11111 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9903 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 10959 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 10714 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10878 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10969 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10793 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10573 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 20000 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9984 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| 7703 | n | n | n | n | n | n | n |
| 9988 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| 10572 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10595 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 9087 | 0 | n | 0 | n | n | n | n |
| 10882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9919 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 10346 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| 9064 | 0 | n | 1 | 0 | 1 | n | n |
| 10733 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 9093 | 0 | 0 | 1 | n | n | n | n |
| 5748 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10233 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 10176 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 10050 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| 10791 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10354 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |

| No. | Subjective Findings<br>A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 10553 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10788 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10399 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 10485 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 10554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10671 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 10736 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 4703 | n | n | n | n | n | n | n |
| 10666 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 9985 | 1 | 1 | 1 | n | 1 | 1 | 0 |
| 9344 | 0 | n | 0 | 0 | 1 | n | n |
| 10639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4381 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9411 | 1 | n | 1 | 1 | 0 | n | 0 |
| 10670 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 9161 | 0 | 0 | 0 | 0 | n | n | n |
| 10638 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 9244 | 0 | 0 | 0 | 1 | 1 | n | n |
| 10646 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10645 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 4005 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 11440 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 10555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11108 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 9124 | 0 | n | 0 | 0 | n | n | n |
| 10423 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10837 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 11075 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9382 | 1 | 1 | 1 | 1 | 0 | n | 0 |
| 11146 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| 10626 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 9163 | 0 | 0 | 0 | 0 | n | n | n |
| 10667 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 9274 | 0 | 0 | 0 | 0 | n | n | n |
| 6429 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10877 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10879 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10740 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10133 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

|  | Subjective Findings |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| No. | A | B | C | D | E | F | G |
| 10989 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 5105 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10047 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 10517 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 7749 | 0 | 0 | 0 | 0 | 1 | n | 1 |
| 9702 | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| 9092 | n | n | n | n | n | n | n |
| 11048 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 10640 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 10840 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9479 | 0 | 0 | 0 | 0 | 0 | n | 1 |
| 10720 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 10282 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9284 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| 10737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10839 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 11004 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10071 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9340 | 0 | 0 | 0 | 0 | 0 | n | n |
| 10627 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 9873 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| 9347 | 0 | 0 | 1 | 0 | 1 | n | n |
| 10174 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| 9128 | 0 | 0 | 0 | 0 | n | n | n |
| 10284 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 9164 | 0 | n | 0 | 0 | n | n | n |
| 9125 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10112 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| 9088 | 0 | 1 | 0 | n | n | n | n |
| 10833 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 9910 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 9162 | 0 | 0 | 1 | 0 | n | n | n |
| 9062 | 0 | 0 | 0 | n | n | n | n |
| 10254 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10998 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10589 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 10048 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 10919 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10571 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

| | Subjective Findings | | | | | | |
|---|---|---|---|---|---|---|---|
| No. | A | B | C | D | E | F | G |
| 11080 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 10643 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10447 | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| 11077 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 10141 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 10732 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 10315 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 10629 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 9606 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 10344 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 9733 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 9202 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10445 | 0 | 0 | 1 | 0 | 1 | n | 0 |
| 9650 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| 11336 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |

## Appendix 9(q)

## Clinical Signs and Symptoms Continued

**Key:**

| | |
|---|---|
| H | Thumbsucking Habit |
| I | Facial trauma history |
| J | Birth trauma as recalled by parents |
| K | Bruxism as stated awareness by parents |
| L | Multiple earaches present or previous |
| M | Multiple ear infections present or previous |

| | Subjective history | | | | | |
|---|---|---|---|---|---|---|
| No. | H | I | J | K | L | M |
| 10631 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10734 | 0 | 0 | n | 0 | 0 | 1 |
| 9309 | n | 1 | n | n | n | n |
| 10140 | 0 | 0 | 0 | 1 | 1 | 1 |
| 10716 | 0 | 0 | n | 1 | 1 | 1 |
| 10962 | 0 | 1 | n | 1 | 0 | 0 |
| 7767 | 0 | 0 | n | 0 | 1 | 1 |
| 9938 | 0 | 0 | n | 0 | 0 | 0 |
| 10569 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10794 | 0 | 0 | n | 1 | 0 | 0 |
| 10495 | 0 | 0 | n | 0 | 1 | 1 |
| 9247 | 1 | 1 | n | n | n | n |
| 9559 | 0 | 1 | 1 | 0 | 0 | 1 |
| 10110 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10491 | 0 | 0 | n | 0 | 1 | 0 |
| 9467 | n | n | n | n | n | n |
| 10570 | n | n | n | n | n | n |
| 10515 | 0 | 0 | n | 0 | 0 | 1 |
| 9700 | 0 | 0 | n | 0 | 0 | 0 |
| 10369 | n | n | n | n | n | n |
| 10392 | 1 | 1 | n | 1 | 1 | 1 |
| 10713 | 1 | 0 | 0 | 0 | 1 | 1 |
| 9129 | n | n | n | n | 0 | n |
| 9713 | 0 | 0 | n | 1 | 0 | 0 |
| 7702 | n | n | n | n | n | n |
| 10575 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10576 | 0 | 1 | n | 0 | 0 | 0 |

|  | Subjective history |  |  |  |  |  |
|---|---|---|---|---|---|---|
| No. | H | I | J | K | L | M |
| 9273 | n | 0 | n | n | n | n |
| 10574 | 0 | 0 | n | 0 | 1 | 1 |
| 9945 | 0 | 0 | n | 0 | 1 | 1 |
| 10741 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10568 | 0 | 0 | 0 | 1 | 1 | 1 |
| 10960 | 0 | 0 | n | 1 | 0 | 0 |
| 10596 | 0 | 1 | 0 | 1 | 0 | 0 |
| 6229 | 1 | 1 | n | 1 | 0 | 0 |
| 9872 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10642 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10549 | 1 | 0 | n | 0 | 1 | 0 |
| 11111 | 0 | 1 | n | 0 | 1 | 1 |
| 9903 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10959 | 0 | 1 | 0 | 1 | 0 | 0 |
| 10714 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10878 | 0 | 0 | n | 0 | 0 | 1 |
| 10969 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10793 | 0 | 0 | n | 1 | 1 | 1 |
| 10573 | 1 | 1 | 0 | 0 | 0 | 0 |
| 20000 | 0 | 1 | n | 0 | 1 | 0 |
| 9984 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7703 | n | n | n | n | n | n |
| 9988 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10572 | 0 | 1 | 0 | 0 | 1 | 1 |
| 10595 | 0 | 0 | n | 1 | 1 | 1 |
| 9087 | n | n | n | n | n | n |
| 10882 | 0 | 0 | n | 0 | 0 | 0 |
| 9919 | 1 | 1 | n | 1 | 1 | 0 |
| 10346 | 1 | 0 | 0 | 1 | 0 | 0 |
| 9064 | n | 0 | n | n | n | n |
| 10733 | 1 | 1 | n | 0 | 0 | 0 |
| 9093 | n | n | n | n | n | n |
| 5748 | 0 | 0 | n | 0 | 1 | 1 |
| 10233 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10176 | 1 | 0 | 0 | 0 | 1 | 0 |
| 10050 | 1 | 0 | 0 | 0 | 1 | 0 |
| 10791 | 0 | 1 | n | 0 | 0 | 0 |
| 10354 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10553 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10788 | 0 | 0 | n | 0 | 1 | 0 |

| No. | Subjective history<br>H | I | J | K | L | M |
|---|---|---|---|---|---|---|
| 10399 | 1 | 0 | n | 1 | 0 | 0 |
| 10485 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10554 | 0 | 0 | n | 0 | 0 | 0 |
| 6796 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10671 | 0 | 0 | n | 0 | 0 | 0 |
| 10736 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4703 | n | n | n | n | n | n |
| 10666 | 0 | 0 | n | 0 | 0 | 0 |
| 9985 | 0 | 0 | 0 | 1 | 0 | 1 |
| 9344 | n | 0 | n | 0 | n | n |
| 10639 | 0 | 0 | n | 0 | 1 | 0 |
| 4381 | 0 | 0 | 0 | 1 | 1 | 0 |
| 9411 | 0 | 1 | n | n | n | n |
| 10670 | 0 | 1 | n | 0 | 0 | 0 |
| 9161 | n | n | n | n | n | n |
| 10638 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9244 | n | 0 | n | n | n | n |
| 10646 | 0 | 0 | n | 1 | 1 | 1 |
| 10645 | 0 | 0 | n | 0 | 1 | 0 |
| 4005 | 0 | 0 | 0 | 0 | 1 | 0 |
| 11440 | 0 | 0 | n | 0 | 0 | 0 |
| 10555 | 0 | 0 | n | 0 | 0 | 0 |
| 11108 | 0 | 1 | n | 0 | 1 | 1 |
| 9124 | n | n | n | n | n | n |
| 10423 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10837 | 0 | 0 | n | 0 | 1 | 1 |
| 11075 | 0 | 0 | n | 0 | n | n |
| 9382 | 0 | 0 | n | 1 | n | n |
| 11146 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10626 | 1 | 0 | 0 | 1 | 0 | 0 |
| 9163 | n | n | n | n | n | n |
| 10667 | 0 | 0 | n | 1 | 1 | 1 |
| 9274 | n | 0 | n | n | n | n |
| 6429 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10877 | 1 | 0 | n | 0 | 0 | 0 |
| 10879 | 0 | 1 | n | 0 | 0 | 0 |
| 10740 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10133 | 0 | 1 | 0 | 0 | 0 | 0 |
| 10989 | 0 | 0 | n | 1 | 1 | 1 |
| 5105 | 0 | 1 | n | 0 | 0 | 0 |

|  | Subjective history |  |  |  |  |  |
|---|---|---|---|---|---|---|
| No. | H | I | J | K | L | M |
| 10047 | 0 | 0 | n | 0 | 0 | 0 |
| 10517 | 1 | 0 | n | 1 | 0 | 0 |
| 7749 | 1 | 0 | n | n | n | n |
| 9702 | 1 | 0 | 0 | 0 | 1 | 1 |
| 9092 | n | n | n | n | n | n |
| 11048 | 1 | 0 | n | 0 | 1 | 1 |
| 10640 | 0 | 0 | n | 0 | 1 | 1 |
| 10840 | 0 | 0 | n | 0 | 0 | 0 |
| 10647 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9479 | 1 | 0 | n | n | n | n |
| 10720 | 1 | 1 | 0 | 1 | 1 | 1 |
| 10282 | 0 | 0 | n | 1 | 0 | 0 |
| 9284 | 0 | 1 | n | 0 | 0 | 0 |
| 10737 | 0 | 1 | n | 0 | 1 | 1 |
| 10839 | 0 | 0 | n | 0 | 0 | 0 |
| 11004 | 0 | 0 | n | 0 | 0 | 1 |
| 10071 | 0 | 1 | 1 | 0 | 1 | 1 |
| 9340 | n | 0 | n | 0 | n | n |
| 10627 | 0 | 0 | n | 0 | 1 | 1 |
| 9873 | 1 | 0 | n | 0 | 0 | 0 |
| 9347 | n | 0 | n | 0 | n | n |
| 10174 | 1 | 0 | n | 1 | 1 | 1 |
| 9128 | n | n | n | n | n | n |
| 10284 | 0 | 1 | n | 0 | 1 | 1 |
| 9164 | n | n | n | n | n | n |
| 9125 | 1 | 0 | 0 | 0 | n | n |
| 10112 | 0 | 1 | n | 1 | 1 | 1 |
| 9088 | n | 1 | n | n | n | n |
| 10833 | 0 | 0 | n | 1 | 0 | 0 |
| 9910 | 1 | 0 | 1 | 1 | 1 | 0 |
| 9162 | n | n | n | n | n | n |
| 9062 | n | n | n | n | n | n |
| 10254 | 0 | 1 | n | 0 | 0 | 0 |
| 10998 | 0 | 0 | n | 0 | 0 | 0 |
| 10589 | 0 | 0 | n | 1 | 0 | 0 |
| 10048 | 1 | n | 1 | 0 | 0 | 0 |
| 10919 | 0 | 0 | n | 0 | 0 | 0 |
| 10571 | 0 | 0 | 0 | 0 | 1 | 1 |
| 11080 | 0 | 0 | n | 0 | 1 | 1 |
| 10643 | 0 | 1 | n | 1 | 0 | 0 |

|  | Subjective history |  |  |  |  |  |
|---|---|---|---|---|---|---|
| No. | H | I | J | K | L | M |
| 10447 | 1 | 0 | 0 | 1 | 1 | 1 |
| 11077 | 0 | 0 | 0 | 1 | 1 | 1 |
| 10141 | 1 | 0 | n | 1 | 1 | 1 |
| 10732 | 1 | 1 | 0 | 0 | 0 | 0 |
| 10315 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10629 | 1 | 0 | 0 | 1 | 0 | 0 |
| 9606 | 1 | 1 | 0 | 0 | 1 | 1 |
| 10344 | 1 | 0 | 0 | 1 | 1 | 1 |
| 9733 | 0 | 0 | n | 0 | 1 | 1 |
| 9202 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10445 | 0 | 1 | n | 0 | 0 | 0 |
| 9650 | 0 | 0 | 0 | 0 | 0 | 1 |
| 11336 | 1 | n | 0 | 0 | 1 | 1 |